JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXI.] JUNE, 1871. [No. 6

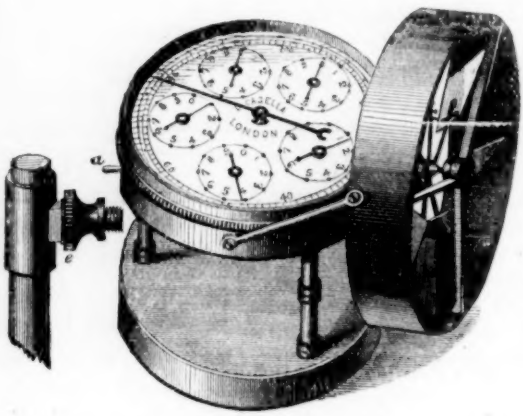
EDITORIAL.

ITEMS AND NOVELTIES.

Fire-proof Safes.—At the last meeting of the *Franklin Institute*, a new device for increasing the fire-proof quality of safes, and of affording additional safety to papers and other valuables stored in them, was exhibited. The improvement which is claimed is effected by placing water in copper vessels between the inner walls of the safe and the book-case; so that when exposed to fire, steam is generated, in which act a large share of the heat is absorbed, and the contents of the safe protected for a considerable length of time from the effects of an elevated temperature. The vessels are hermetically sealed with a fusible solder, which melts and opens the steam valves just before the water boils, but which effectually prevents evaporation, keeping the safe dry till the fire occurs. Return tubes, ingeniously arranged, preserve the water from running out, in the event of the safe falling on its side or top in burning.

The principle here relied upon to increase the efficiency of safes, is the property which water more than all other bodies possesses, of absorbing heat in the act of becoming steam. The action of the vessels is designed to be that the steam shall convey the heat from the safe as rapidly as it is given to it; no more heat being left to penetrate through the water vessels than is needed to produce the steam capable of being generated by it.

Castella's Air Meter.—The accompanying illustration represents a very useful and compact form of air-meter, designed and manufactured by Castella, of London, the object of which is to give correct means of measuring the velocity of currents of air passing through mines, the ventilating spaces of buildings, &c. It was first constructed for Dr. Parkes, F. R. S., for the purpose of measuring the state of ventilation in one of the government establishments in England, and with such good results that it has been extensively introduced in that country and elsewhere for a similar purpose. One of these instruments, imported, amongst other things, for the Stevens Institute of Technology, was exhibited at a late meeting of the *Franklin Institute*, and elicited general admiration for its extreme delicacy.



The graduations for each instrument are obtained by actual experiment by means of machinery made for the purpose, so that the indications of all are as comparable with each other as the weight or measure of ordinary substances.

The indications are shown by means of the large dial and hand and five smaller ones, as shown in the annexed figure. The whole circumference of the large dial is divided into 100 parts, and represents the number of feet up to 100 traversed by the current of air. The five smaller dials are each divided into ten parts only, one revolution of each being equal to ten of the preceding dial, and

representing 1000, 10,000, 100,000, 1,000,000 and 10,000,000 respectively. By means of the large dial the low velocity of fifty feet per minute may be measured, and by the smaller ones continuous registration is extended up to 10,000,000 feet, or equal to 1893 miles; being practically beyond what the most extended observations can require, whilst jewelling in the most sensitive parts insures the utmost delicacy of action.

By moving the small catch *a* backwards or forwards the work is put in or out of gear without affecting the action of the fans; this prevents the injurious effect of stopping them suddenly, and enables the observer to begin or end his observations to a second. A small handle with universal joint accompanies the instrument, and may be screwed in at the base; by putting a stick through this, it may be raised or lowered to any required height and used in any position.

The Nicaragua Route.—The pages of Col. O. W. Childs' Report on the Survey of the Nicaragua Route for a Ship Canal still remaining unpublished in our columns, we believe to be of such a character as would prove uninteresting to our readers, and the further publication of the report will therefore be discontinued. What remains consists entirely of details, mainly tabulated, of earthwork, dams, etc., with estimates of the cost of the separate portions of work. As the whole of the general report has been reproduced in full, together with the cost estimates for the several branches of the work, and of the total expenses, it is believed that as much of the report has been presented to our engineering readers as will prove of use to them for the purpose of reference.

A Tunnel under Boston Bay.—An exchange tells us that a tunnel is projected to connect East Boston with Boston. The expense is estimated at $2,000,000, while the ferries, which are free now, cost $100,000. The plans have been made with two tubes, each with an inside tube of twenty-one feet, and to accommodate horse cars, teams and pedestrians.

Photometry in Rail Making.—The *American Gas Light Journal* contains a short item which is quite interesting as noting the application of one art to the service of another, where not the slightest relation would have been suspected. It is namely, that in the rolling mills for iron rails in Russia, a form of photometer is in use for the purpose of determining the exact temperature at which the rails must be sawed off, in order that their lengths shall be uniform.

Gun-cotton and Gunpowder.—Our English cotemporaries record some interesting results of experiments conducted at the Royal Arsenal at Woolwich, in order to decide how far Abel's compressed gun-cotton, which has recently been considerably introduced in the military service, is liable to explode in bulk, by simple ignition; and also whether or not the explosion or ignition of one case of gun-cotton would cause the explosion or ignition of neighboring cases.

The only experiment we have space to record is that which follows: A quantity of compressed gun-cotton was packed in wooden cases, containing 28 pounds each, which, as regards explosive power, is equivalent to about 112 pounds of gunpowder. In the first instance, one of these 28 pound cases, the lid of which was tightly screwed down, was ignited. There was a sudden burst of bright flame, which opened the box without destroying it, and without causing anything of the nature of an explosion. After this, eight cases, each containing 28 pounds of gun-cotton, and two cases containing each 28 pounds of damp gun-cotton, were placed on the ground, and covered and surrounded by thirty-two more boxes, each of which contained a quantity of sand equal in weight to 28 pounds of gun-cotton. The object was to imitate as nearly as possible the condition of things in a magazine of gun-cotton, where a number of cases would be piled together, and one of them might be accidentally fired. The ignition of one box caused a sudden rush of bright flame, which penetrated through the pile, and was followed by another rush of flame, due to the ignition of the contents of another box—without any explosion. The result on examination proved to be only a partial disturbance of the pile on one side and the ignition of the contents of only one box in addition to the box full of gun-cotton purposely ignited. The gun-cotton in the six remaining cases had not been ignited, nor had the damp gun-cotton. If any one will take the trouble to consider what would have been the effect of exploding a barrel of gunpowder in the midst of seven other barrels of gunpowder, closely packed and built up into a pile with other barrels, he will be able to appreciate the exceptional and very satisfactory behavior of the gun-cotton in this experiment.

The new Caisson of the East River Bridge.—To prevent and extinguish fire, which under the high pressure of air almost proved destructive to the former caisson, the new one has been pro-

vided with a lining of boiler iron. As a second safeguard, a series of pipes is distributed through the structure in such a way that a large stream of water can be readily turned on.

A new danger to Ocean Cables.—A recent announcement of the Superintendent of the International Telegraph Company between Punta Rosa and Key West, according to a notice in the *Iron Age*, has placed a new item upon the list of dangers to which ocean cables may be subjected; and against which suitable provision will have to be made.

The cable in question had, during the past year, been so frequently injured or broken, that a careful examination was decided upon, the result of which was to the effect that the damage was to be ascribed to the loggerhead turtles, which are abundant in those waters. In many places the cable presented the appearance of having been bitten through; and in others of having been crushed from both sides, until it had become so much flattened as to destroy its conductivity. The conclusion of Col. Heiss, the superintendent, is further confirmed by the fact that at the depths where the breaks and injuries occur, there the loggerheads most abound. Our cotemporary remarks, in conclusion, of this unforeseen source of danger, that the International Company, whose line has been so badly chewed up by the turtles, have sent an order to New York for a much larger and stronger cable, and when it is laid the assailants will have something more substantial than the present steel-wound cable upon which to whet their teeth.

The Census Enumeration of 1870.—From the recent tables issued by the Census Bureau at Washington, it appears that the total population of the United States is 38,538,180, showing an increase within the last decade of 7,094,859. In relation to population, a comparison of the condition of the various sections of the country with the enumeration of 1860, furnishes some instructive facts. The New England States are about at a stand-still, New Hampshire and Maine even showing a small decrease. The Middle and Southern States are slowly increasing, while the great increment has added itself to the Western States and Territories. The following tabulation will show the totals for both enumerations:

	1870.	1860.	Gain pr. ct.
Total of Territories,	422,500	259,577	
" " States,	38,059,680	31,183,744	21·1
" " United States,	38,538,180	31,433,321	22·6

The Mass of the Moon determined from observation of Tides, by Wm. Ferrel.—At the meeting of the National Academy of Sciences, on the 19th of April, 1871, Mr. Wm. Ferrel, of the United States Coast Survey, gave an account of his discussion of tidal observation with reference to determining the mass of the moon. He used in this investigation a series of observations made for the Coast Survey during nineteen years—a full lunar cycle, at Boston, Mass., and a similar series of observations made at Brest, France, from 1812 to 1831, inclusive.

Without going into the mathematical form of the investigation it will be readily seen that the moon's mass must be mainly inferred from the ratio which the spring and neap tides bear to the constant or average tides. This ratio, however, does not depend entirely upon the moon's mass, but varies greatly for different ports, the heights and times of the tide being modified by local circumstances, and consequently the tides have not been hitherto considered an available means for determining the mass of the moon.

In addition to the constant to be determined by observation, introduced into the conditions by Laplace for determining the moon's mass, Mr. Ferrel has introduced another depending upon friction. Hence, there being three unknown quantities to be determined, including the moon's mass, he uses the condition depending upon the moon's parallax in addition to the two used by Laplace. Without the introduction of this additional constant and the additional condition for eliminating it, Laplace's conditions for the determination of the moon's mass entirely fail when applied to the Boston tides.

Laplace selected Brest, where the tide has a direct and short approach from deep water, and neglecting the effect of friction referred to, obtained, as is well known, the value, $\frac{1}{74{\cdot}96}$ in terms of the earth's mass for the mass of the moon. At Brest the ratio of the half-monthly inequality to the co-efficient or half-range of the constant tide is about ·358, that of the constant tide being about 2·25 metres, and that of the mean spring tides being about 3·05 metres. At Boston the same ratio is only about ·14, the co-efficient of the constant tide being 4·91 feet, and that of the mean spring tide 5·58 feet. From data so widely different, Mr. Ferrel has deduced, by means of the introduction of the term depending upon friction, two values exhibiting a remarkable agreement, viz., from the Brest tides, $\frac{1}{77{\cdot}14}$; and from those at Boston, $\frac{1}{78{\cdot}64}$

The former value has the greater probability, as small variation in the observed height has a much less effect upon the inferred value of the moon's mass at Brest than at Boston. The most probable value that can be inferred from Mr. Ferrel's discussion may be taken as $\frac{1}{77{\cdot}5}$

For comparison, the determinations by other methods may be quoted. From the observed co-efficients of the principal term of lunar nutation by different astronomers, we have the corresponding masses of the moon:

	Co-efficient of nutation.	Mass.
Brinkley, . . .	9·25	$\frac{1}{79{\cdot}3}$
Peters, . . .	9·222	$\frac{1}{81{\cdot}1}$

From the following observations from determinations of the lunar co-efficients in the solar tables, we have the corresponding masses of the moon, assuming the solar parallax equal to 8″·85.

	Co-efficient.	Mass.
Burckhardt, . .	6·80	$\frac{1}{77{\cdot}4}$
Airy, . . .	6·46	$\frac{1}{81{\cdot}5}$

The Misuse of a Symbol.—Captain William Noble has communicated a note upon this subject to the Royal Astronomical Society,* in which he very properly records his protest against the very common misapplication of the mark ″.

The legitimate signification of this symbol is, as no one will dispute, seconds of *arc*, but in numberless papers in our different scientific journals, it is used indiscriminately to designate, not only its proper term, but seconds of *time* and *inches* as well. That this misuse of the mark in question may readily originate ambiguity will appear from the following extracts, which we are sure any of our readers can duplicate *ad libatum*:—A certain observatory is stated to be 24″ E. of Greenwich, while as a matter of fact it is 24 seconds of *time* east of that meridian, and not 1·6 seconds, as would follow from the true meaning of the symbol. It is very common to speak of a 4″ lens, meaning, of course, a lens having a focal length of 4 inches. In the present ambiguous application of the symbol, it would be safe to assert that the lens in question subtended an angle of 4 seconds of arc, and that the observatory referred to, was 24 inches east of Greenwich.

*See their Notices, Vol. XXXI, p. 134.

The proper terms expressing the examples instanced, it is hardly necessary to add, are ″ for seconds of arc, sec. for seconds of time, and in. for inches.

Employment of the Spectroscope to determine the quantities of substances.—The use of the spectroscope to detect minute traces of substances has been the most glorious achievement of the chemistry of the last decade; perhaps its employment to determine minute quantities may be the great exploit of the next. As an essay in this direction, may be noticed the interesting contrivance of K. Vierordt,* who divides the movable plate of the slit of the spectroscope into an upper and lower half. Each half is provided with a micrometer screw, by which the width of the corresponding slit can be accurately measured. If the upper and lower slit are of the same width, the two spectra are of equal strength. If, however, a transparent colored medium be brought before the upper slit, for example, a tinted glass, a thin plate of any colored body, or a solution of a colored substance in a tank with parallel sides, we have two spectra of different intensities. The other slit is now diminished by the motion of the micrometer screw until the spectra are made equal in strength, and by comparison the amount of this motion is made to give the amount of coloring matter present. A. R. L.

Solvent for Indigo.—The extensive employment of indigo makes it important to notice some new solvents which V. Wartha† has recently found for it. In the first place, Venetian turpentine, heated to the point of ebullition, dissolves indigo with the same blue color as does sulphuric acid or aniline. After cooling, magnificent copper-red crystals separate. The crystals can easily be freed from the solvent by ether or alcohol. Boiling paraffine is an equally good solvent. A somewhat dilute solution of indigo in paraffine can with difficulty be distinguished from alcoholic solution of fuchsine. After cooling, the separated needles can be cleaned with benzol, etc. Petroleum dissolves indigo with carmine red solution; so also spermaceti and stearic acid, the first with carmine violet, the last with blue color. A. R. L.

Itacolumite.—A specimen of this rock has lately come to our hands from North Carolina, which seems worthy of notice from its extreme flexibility. The specimen in question is a very com-

* Ber. der deutsch. chem. Gesell. IV., No. 6, p. 327.

† Ber. der deutsch. Chem. Gesell. IV. No. 6.

pact, fine-grained variety, in which the lamination can only be detected with difficulty. The dimensions are: length, 7 inches; width, 2 inches; thickness, $\frac{1}{3}$ inch. The amount and variety of its motions are quite surprising. Not only may it be bent in the plane at right angles to that of its lamination, but in the plane of lamination also; and if a torsional strain is applied to the ends, the rod obeys the pressure quite perceptibly.

The Reversal of the Sodium Line.—The ordinary method of reversing the sodium line, namely, that in which some weakly luminous sodium vapor is brought between a white-hot body and the slit of the spectroscope, demands that the white light shall possess considerable brilliancy, in order that the sodium vapor shall absorb a much greater quantity of light than it emits, and the sodium line thus possess a feebler luminosity than the neighboring portions of the spectrum.

It is to be expected that this reversal will take place far more readily if, by any means, the brilliancy of those portions of the spectrum in the neighborhood of the D line can be increased to the same extent as the brilliancy of the sodium line is increased by the luminosity of the sodium vapor.

According to A. Weinhold,* this condition of things can be brought about in the following simple manner: Place before the slit of a small spectroscope (consisting only of the pierced tube without lens, and a prism of good dispersive power) a small petroleum lamp; then bring an alcohol flame strongly charged with salt, in such a manner between the prism and the eye that the whole spectrum shall be covered by it, and then instantly a well defined, dark sodium line makes its appearance: while the same alcohol flame, if placed between the petroleum lamp and the slit, produces a bright line.

Artificial Coloring of Wines.—The methods in general use for the detection of the artificial treatment of wines, to counterfeit those of better quality, are so universally unreliable that the mention of a recent method proposed by T. L. Phipson,† which seems worthy of recommendation, may prove of interest. The chemist in question proposes to examine the wine spectroscopically. It is declared that the natural coloring matters of wines produce no definite absorption bands, but only a very general absorption of the spec-

* *Pogg. Ann.*, CXLII., 321.

† *Chem. News*, XX, 229.

trum, which is greatest towards the violet end of the spectrum; while, on the contrary, the coloring matter of Brazil-wood, &c., generally used in this counterfeiting process, produce very decided and easily recognizable absorption bands. The method of testing which he recommends is to add water, if the wine is too dark, until it is sufficiently transparent, and then to examine it; and states that every wine is to be regarded as suspicious in which the least sign of an absorption-band appears.

A. Faccen* has given another method with the same object in view, which consists in treating the wine with an equal weight of coarsely-powdered black oxide of manganese, and stirring the mixture for about ¼th hour. It is asserted that wines with natural coloring matters will be completely discolored, while those which are artificially colored always remain more or less colored after filtration. It is, however, to be mentioned, that the efficiency of this latter method has been denied. The first may prove of great value.

The Nitro-Chromic Battery Fluid.—Its practical working.—The accompanying letter in relation to this subject may prove of interest:

Office Superintendent Fire Alarm Telegraph,
New York, August 11th, 1870.

W. GOOLD LEVISON, Esq.: *Dear Sir*—You will probably remember that in the latter part of June or early part of July, 1869, you described to me a battery you were then experimenting upon, which seemed to me to be part Grove and part Electropoion. Since that time I have been so very busy that the matter passed from my mind.

It gives me pleasure to say that since our late conversation, which revived clearly your former explanation, I have tested the battery, and, following your directions strictly, have, to my surprise, developed an indestructible LOCAL battery.

On the first day of the present month I put up your battery, viz., filled up the porous cup around the coke with bichromate of potash, filling up with nitric acid, then in the glass jar, a solution of sulphuric acid 1 to 10. At the same time I put up the same number of cups (five) of the electropoion battery.

Testing each battery through galvanometer with 38 miles of resistance, I found that each marked 40°. I then placed 3 cups of your battery in service (working two machines), and 2 cups short

* *Fresenius Zeitsch*, IX, 121.

circuited, with six inches of wire. These remained so for 20 hours; after which the 3 cups showed 28° and the 2 cups 10° *through same resistance.* I then for the same length of time, placed the electropoion battery, 3 cups in service and 2 short circuited, and my tests then showed the elec. 3 cups to be 23° and the two cups DEAD. The new battery, on being tested at this time, showed 3 cups *thirty* degrees, 2 cups FIFTEEN degrees.

I have this afternoon found the 5 cups electropoion DEAD, while the *new* battery is in such good condition that I have put the 3 cups in service again, and the 2 cups on short circuit. That the tests should be as perfect as possible, I directed that neither should be renewed or aided in any manner. When I shall have succeeded in killing the two cups, I will send you word. To my further surprise, the *new* battery shows the cokes, for full two inches below the clamp connection, to be perfectly dry, and not a sign of formation of chrome alum, while in the electropoion battery the cokes became saturated before the first test was made, and now have a large deposit of chrome alum on the clamp connections.

I propose to make some very close and severe tests, the result of which I will communicate.

It affords me great pleasure to lay before you the foregoing facts, and also to congratulate you upon the discovery of a *local battery*, which, for its great endurance, steadiness of action and economy, must soon be universally adopted. I am very truly yours,

CHARLES L. CHAPIN,
Sup't F. A. Telegraph.

Solid Bi-Sulphide of Carbon.—A curious process of bringing about the congelation of a number of volatile compounds, and which appears to have the fortune of being periodically re-discovered and announced, is that of blowing upon them a jet of air. Treated in this way, bi-sulphide of carbon, chloroform, iodide of ethyl, and other volatile liquids, may be rapidly evaporated, but where the blast of air parts the surface, a floculent, snow-like solid makes its appearance, and finally remains behind in the vessel.

The temperature during the process of evaporation sinks very rapidly, the bulb of the thermometer coating itself with the solidified substances, and a cold of —10° to —12° C. can be readily produced. The solid thus obtained slowly liquifies, retaining all the while a temperature much below the freezing point of water.

The nature of the body thus obtained is a question still in dis-

pute. Taking the bi-sulphide of carbon as the example, it is found that the solid obtained from its evaporation in the air always contains a quantity of water, this quantity is, however, not a constant one, but varies from 5 to 30 per cent. The questions in dispute are now: is the solid obtained essentially frozen bi-sulphide of carbon, in which some condensed and frozen water is mechanically suspended; is it a solid hydrate of the bi-sulphide; or, lastly, is the solid simply frozen water in which is suspended minutely divided particles of the liquid bi-sulphide, which by rapid evaporation cause the low temperature?

The question is not one so easily decided; seeing that solid bi-sulphide of carbon can readily be produced free from water with the aid of the air-pump. Some of the objections, too, which are urged against the proposition to term the substance solid bi-sulphide, may be urged with equal propriety against the solid carbonic acid, which is formed, as is well known, by allowing the gas liquified under powerful pressure to stream through the air into an appropriate reservoir. The solid carbonic acid is formed under very similar conditions to those in the experiment we are considering, and always contains a variable per centage of water. Yet no one has doubted the existence of the solid carbonic acid because of the frozen water it contained. An assertion of a positive character would hardly be justifiable while the matter is still under investigation; but from all that has thus far been advanced, it would appear that the weight of evidence is in favor of the view, that the product obtained by the air blast is really solid bi-sulphide, chloroform, &c., in which is mechanically suspended a variable quantity of frozen water. In conclusion, it may be remarked that in a few experiments which we have performed in this direction with ether, although a temperature of —8° C. was obtained, not the slightest appearance of solidification was observed, but liquid could easily be brought to the consistency of syrup.

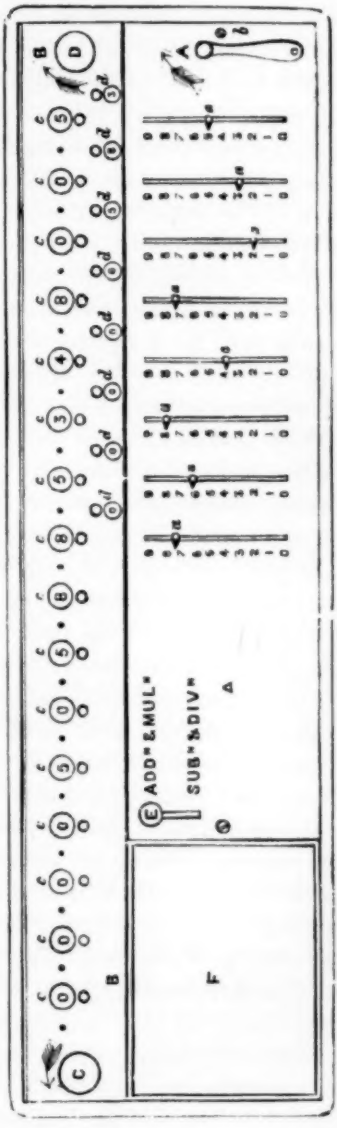
The Arithmometer.—Some of our readers may perhaps already have heard of this calculating machine, the invention of the late Monsieur Thomas de Colmar. A few remarks, therefore, on its construction and operation may be of interest.

The instrument is of small size, the one which we are about to describe being only 22 inches long, 6½ inches wide, and 3½ inches deep.

With its aid eight figures (tens of millions) can be multiplied by

eight figures in eighteen seconds; sixteen figures be divided by eight figures in twenty seconds, and a square root of sixteen figures be extracted, with the proof, in less than two minutes.

The instrument is much used in England and Europe generally, in government offices, in observations, in most of the life insurance offices, and in those of civil engineers and others.



Our illustration shows a top view of an Arithmometer, the lid of the box being removed. It is constructed chiefly of a brass plate A, furnished with eight slots, as shown; directly under these slots are mounted eight drums, each having nine elongated cog teeth of successively decreasing length; over each drum, and between it and the slot, is mounted a square shaft, on which slides a pinion-wheel, so as to catch any number of teeth on the drum. Each of these pinion-wheels is moved by a button *a*, of which there is one in each slot, the figures at the sides of the slots showing the proper position of each button *a*, for any work to be performed by the instrument. The cogged drums gear by bevel-wheels with a long horizontal shaft, which is also in gear with the vertical shaft moved by the handle *b*, by which the instrument is worked. B is a moveable brass plate, which can turn and slide on a round bar hinge at the back; in this plate there are 16 holes *c*, under each of which is a moveable disc, numbered from 0 to 9, and arranged so that any one figure of each disc may be brought

under its corresponding hole, *c*. These discs have bevel-wheels which gear with bevel-wheels on the before mentioned square shafts. The moveable plate B is also furnished with the holes *d*, having disks numbered from 0 to 9 underneath, and are for showing the number of turns of the handle, giving by this means the quotient in division and showing the multiplier in multiplication. The knobs C and D are for bringing the figures under the holes *c* and *d* to zero before commencing an operation, and the knob E is for setting the instrument to work addition and multiplication, or subtraction and division; F is a small slate for memoranda.

Before further describing the working of the machine, we would remark that if the knob E be placed at addition, each turn of the handle will carry the figures marked by the buttons *a* under the indicator holes *c*, while if the knob be placed at subtraction, it will subtract from the figures under the holes *c* the number marked by the buttons *a*.

We will now proceed to give an example of the operation of multiplications, the operations for addition and subtraction being sufficiently explained in the previous paragraph.

Thus to multiply 76,847,235 by 6583: Mark the multiplicand on the plate A by the buttons *a*, as shown in the illustration; set the knob E at addition and multiplication, then turn the handle *b* three times for the unit figure of the multiplier, and three times the multiplicand, viz: 230541705, will appear under the holes *c* in the movable plate B; this plate must now be raised and moved one figure or station to the right, and the handle turned eight times for the second figure of the multiplier, and 6378320505 will appear the holes *c;* move the plate B again to the right, and turn the handle five times for the third figure of the multiplier, and 44801938005 will be brought under the holes *c*, and finally by moving the plate B once more to the right and turning the handle six times for the last figure of the multiplier, the total product, 505885348005, will appear under the holes *c*, and the figures of the multiplier, viz: 6583, will appear in the holes *d*.

For division the operation is as simple as for multiplication, and is performed as follows: Thus to divide 414591904 by 4768, set up the dividend on the plate B and the divisor on the plate A, commencing with the unit figure in each case to the right hand; place the knob E at subtraction and division, and move the plate B to the right until the second figure (from the left) of the dividend is over

the first figure (4) of the divisor; turn the handle eight times, and an 8 will appear in one of the holes *d*, and will give the first figure of the quotient, while the dividend will now show 33151904, having been reduced by eight times the divisor, as in ordinary arithmetic; move the plate B one place to the left, and turn the handle six times for the second figure of the quotient, and the dividend will be further reduced by six times the divisor, and will mark 4543904; again move the plate and turn the handle nine times, and after moving the plate B and turning the handle five times and three times respectively, the holes *c* will all show noughts, and the quotient holes *d* will show 86953, which is the quotient required; if there had been any remainder it would have appeared in the holes *c*.

Although by the ordinary limits of the machine, a product of 16 places of figures and a quotient of 9 figures only can be obtained, yet by intermediate record by the operator, these limits may be virtually doubled for multiplication, while for division, provided the divisor does not exceed eight places of figures, the dividend and the quotient may be unlimited.

We have not space to enter more fully into the further applications of the instrument, but believe that Mr. W. A. Gilbee, of 4 South street, Finsbury, London, is the sole agent for England and America, and from whom, therefore, any explanations could be obtained.

The Bancker Collection.—For many years past there has existed in Philadelphia, and known only to those of its citizens more especially interested in scientific pursuits, a collection of philosophical and chemical apparatus unequaled in this country, and, if the opinion of foreign savans be taken, without a rival in the world. It was made and owned by the late well-known Charles N. Bancker, Esq., who devoted all the leisure hours of a life extended far beyond the average lot of man, and constantly applied to the successful prosecution of business, to the cultivation of scientific knowledge. For more than half a century he imported from the workshops of Europe their choicest productions in the way of apparatus, and his interest was not limited to one, but extended to all the sciences embraced within the scope of philosophic inquiry.

In this collection will be found cabinets of minerals, with beautifully executed models in glass and wood, to exhibit the immense variety of crystalline forms; charts and maps in relief, with suits rocks to illustrate the geology of various countries; telescopes and

instruments for observing the star, with orreries and globes for studying the motions of the heavenly bodies; models of pumps, rams, jets, mills, and all manner of contrivances to demonstrate the properties of fluids when in rest and in motion. The collection also contains magnets simple and compound, with machines of the most varied description, to illustrate the phenomena of electricity and magnetism. But above all, it is rich in optical and acoustic apparatus. The Abbé Moigno, a distinguished French savant, wrote of it some years ago in *Cosmos*, that "this collection of optical instruments is certainly the most extensive and most brilliant that exists in the world. It embraces in itself more riches than all our cabinets of France, and perhaps of Europe, united. And its venerable founder, whose zeal seems to grow with his age, does not cease to gather the freshest novelties.

"We exaggerate nothing when we estimate the optical treasure of Mr. Bancker at many hundred thousand francs. Besides illustrating the history of optical discovery and research during the present century, it contains numbers of the most valuable and efficient instruments, such as the saccharimeter of Dubosq, the polarizing apparatus of Dove, Powel and Soleil, microscopes by Zentmayer, Smith and Beck, &c., and complete sets of apparatus and objects for repeating the researches of Becquerel and Stokes on phosphoresence and fluoresence. Professor Henry, President of the Smithsonian Institution at Washington, says in a recent letter:—'I am free to say that with the addition of a very few articles that have been improved or invented within the last few years, it would be the most complete series of instruments that I know of for the illustration of the phenomena and history of physics.

"To break up the collection and dispose of it piece-meal, would be a matter of much regret, since the value of the instruments is enhanced by the fact of their being part of a series well adapted to the illustration of the order of the development of science."

Fortunately for the interests of science, the wish of Prof. Henry has been, to a great extent, realized. The entire collection of optical and acoustic apparatus has been purchased by Professor Morton on behalf of the Stevens Institute of Technology, at Hoboken, and is now thrown open to all the students who may wish to prosecute investigation and researches within the walls of that great institution

Civil and Mechanical Engineering.

ON THE USE OF PULVERIZED FUEL.*

By Lieut. C. E. Dutton, U. S. Ordnance Corps.

Having been invited by Messrs. Whelpley & Storer, of Boston, to visit their establishment, and examine their new method of applying fuel to metallurgical and other purposes, I have been so profoundly impressed with the results of the experiments witnessed that I take the liberty to lay before the society a discussion of the subject. Their method consists in pulverizing the coal to an extreme degree of fineness, and blowing it into the combustion chamber, where it is ignited and burned in the air which floats it.

The generic idea involved in this process is not new, for it has, during the last forty years, been made the subject of numerous patents in England,† and possibly elsewhere. But to most practical minds it will certainly appear to be new, and will at first receive the hasty judgment passed upon new ideas. Yet nothing can be more certain than that the principles upon which are based the claims of superior economy and efficiency in this mode of utilizing fuel, are entirely sound, and are demonstrable by well known laws of thermodynamics, and by practical considerations familiar to every educated engineer. Although known to some of the highest class of engineers, and considered by them as "theoretically" sound,

* A paper read before the Franklin Institute, at its stated meeting April, 1871. Being an examination of the method of applying pulverised fuel to furnaces and boilers invented by Messrs. Whelpley & Storer.

† In the year 1831, one J. S. Dawes took out an English patent for applying pulverized fuel to the blast furnace through the tuyeres. It proved unsuccessful, owing doubtless to the fact that the agency of fuel in the blast furnace is chemical as well as physical. In 1846 a patent was taken out by one Desboissiers, for pulverizing fuel, and blowing the dust into the furnace, but though the conception involved some correct ideas, the machinery was totally impracticable.

In 1854, Mouchel suggested the injection of powdered fuel and ores, either separately or together, upon a hearth, or inclined plane of a cast-iron box, heated by waste heat from other furnaces.

Mushet proposed, in 1856, to use pulverized coal, carried by the blast into a reverberatory furnace, to prevent the oxydation of the iron. Other intermediate inventions have been patented in England, but no progress made, owing to the difficulty of pulverizing.

yet it has received particular attention in but few cases, owing to the want of practical means of carrying it into effect. The invention of Messrs. Whelpley & Storer has overcome this practical difficulty in a manner so surprising and complete that it seems well worthy of being ranked in importance and value with the discoveries of Bessemer and Siemens. The defect which has hitherto rendered this valuable idea a practical nullity has been the want of a contrivance for pulverizing coal with uniformity and cheapness. It needs but a moment's reflection to be satisfied that crushing by stamps, or by rolls, and grinding with stones, would cost far more than the best results we could hope to gain—let alone the difficulty of transvecting the dust from the pulverizer to the furnace—a matter no less important than pulverizing itself. Let us see how the invention in question annihilates these difficulties.

Conceive an ordinary blowing fan with the following modifications. The box is about 18 inches diameter, and about the same length. Instead of opening at both ends, one end is tight around the journal. The box is divided into two chambers by a diaphragm, so that, really, we have two fans on the same shaft, and their boxes communicate by a hole in the diaphragm around the shaft. The fan at the closed end of the box is, in form and function, a blowing fan. The outer fan is the pulverizer. The coal is fed into the open end of the pulverizing chamber, is caught by the swiftly revolving paddles, and reduced to powder, and is then sucked by the fan through the diaphragm, whence it is expelled by the ordinary tangential pipe along with the blast. The coal is fed in the form of coarse gravel; it is delivered as fine as flour.

The mere statement of the facts in the case at first appears singular. Had any person, who never saw or heard of this contrivance before, been asked to give his opinion as to what could be the result of feeding coal into such an apparatus, he surely would not have predicted the results actually obtained. It would have been quite natural to expect a little splintering of the coal, and the speedy clogging of the pulverizing chamber, or perhaps the destruction of the whole machine in its efforts to clear itself of its contents. But as the truth is quite otherwise, we may well ask by what kind of action is the coal reduced to powder? It is not ground, for the machine is expressly constructed to avoid a grinding action, the paddles being in no case nearer to the walls of the cylindrical shell than half an inch; nor does the coal seem to be comminuted alto-

gether by splintering against the iron surfaces, for although such action undoubtedly takes place at first impact, yet when it has reached a certain stage, and that by no means near the ultimate one, it cannot seemingly continue to any material extent. The only explanation occurring here, and that not at all satisfactory, is, that in the powerful commotion produced by the swift rotation of the paddles, the particles clash fiercely together and triturate each other—a view confirmed in some measure by the appearance of the dust under the microscope. But whatever the mode, it is certain that the coal is pulverized to an extreme degree. I have watched this machine for hours, and have caused it to be fed under my own eye, and the products collected in a bag, of which I submit a sample. As nearly as I can estimate by microscopic measurement, fully nineteen-twentieths of the particles are less than $\frac{1}{500}$ of an inch in diameter, and none exceed $\frac{1}{150}$ of an inch. From the open end of the pipe it floats away in a dense cloud of smoke, and, singularly enough, not a black smoke, but of a reddish brown color, differing strikingly from the jet black of coal. This may, or may not, indicate extreme minuteness of subdivision; I offer no explanation of it. The still more astonishing performance of this machine in re-reducing quartz, ores, grain, &c., will be alluded to hereafter.

The function performed by this machine is a double one. It pulverizes the fuel and delivers it, along with the blast, into the combustion chamber, by a single and indivisible operation. This combination of two acts into one is of vital importance, and may be said to constitute the central idea of the mechanical part of the process. It would otherwise be useless for metallurgical or even for calorific purposes. It removes at a single *coup* the two most formidable obstacles which have hitherto rendered the use of pulverized fuel impracticable. Another feature of high importance is the mechanism for regulating the supply of air and coal. The inventors have devised an excellent apparatus for this purpose, which controls both with precision; but as this is merely a matter of mechanical detail, I presume it will be taken on trust, and a description of it is omitted. I shall confine myself to a description of the functions performed by it, which are greater than would at first appear. The pulverizer seems to be governed by very definite laws, and a precise practice, in the amount of work it can perform with economy. A machine, working upon a given fuel, will have its efficiency modified by three variable conditions:

1st. The velocity of the shaft.

2d. The quantity of coal introduced.

3d. The quantity of air introduced.

1. With regard to the first condition, practice has shown that there is a uniform, or nearly uniform, velocity suitable to every machine, which may be set down at about 10,000 feet per minute for a point on the periphery of the paddles, which, for an 18-inch pulverizer, would be about 2100 or 2200 revolutions per minute. If the speed be diminished, then the coal will be less thoroughly pulverized, and will burn imperfectly and wastefully in the furnace. If the speed be increased, the fineness of the dust will also be increased, but the power required to attain a higher velocity increases in a very large ratio, and the increased fineness of the product is not sufficiently advantageous to compensate the cost of increased speed.

2. The feed of fuel will of course be determined primarily by the requirments of the furnace, and the minimum quantity which will effect the desired temperature will, in each case, be determined experimentally. If the fuel be diminished, an insufficient heat will be obtained, and if it be increased, the loss will be three fold: (1) the surplus fuel will burn to waste; (2) the effort of the machine to clear itself from an overwhelming supply will absorb more power; and (3) drive out the coal before it is sufficiently pulverized—in brief, the result being, more power and more fuel consumed, and less heat developed.

3. The amount of air admitted should be sufficient to float readily the pulverulent coal, but not more. If excessive, the increased draft through the pulverizing chamber will float out much larger particles than can burn efficiently. Generally speaking, it is advisable to keep the supply of air quite small. In any event it will be necessary to supply air for combustion by a separate air pipe, because, if a sufficient quantity were passed through the machine, it would carry out the fuel insufficiently reduced, and moreover, in special applications it becomes necessary to use hot-blast, which would necessarily enter the furnace through a separate pipe—the air from the pulveriser being always cold. Air enters the pulverizer through the same inlet, and along with the coal. The aperture is adjustable, as is also the feeding apparatus, thus affording perfect and instantaneous control over the supply of both. The advantage of being able to stop a fire completely in an instant, and renew it in full force as quickly, and also to regulate it at pleasure, by the

mere motion of a valve, or hand lever, is so great as to need the merest mention in order to be appreciated.

The pulverizer has been applied by its inventors to a variety of purposes, of which I shall discuss two, which seem to afford the widest range for possible advantages, viz: its application to the reverberatory furnace, and to the steam boiler.

I. *Pulverized fuel in the reverberatory furnace.*—This application does not involve a radical change in the structure and design of the furnace; the chief alteration being the omission of the fire-place in its present form. Instead of constituting a large proportion of the entire structure, and of prime importance, it is reduced greatly in size, and performs subsidiary functions. It is employed, at first, to raise the temperature of the walls to redness around the coal tuyere, which is necessary in order to ignite the dust as it enters the furnace. Subsequently it is kept closed as tightly as possible, and the fuel within it serves merely to deoxydize the air, which filters through the doors, and to supply a small quantity of carbonic oxide. This small supply of inflammable gas materially assists and insures the speedy ignition of the coal dust.* The gas generator is supplied with anthracite culm, of which it consumes only about 30 pounds per hour. The pulverizer is located a few feet behind the gas generator, and the coal tuyere enters the back wall of the furnace, pointing directly over the fire bridge. The air tuyere is located just above the coal tuyere. The furnace, therefore, is reduced to a hearth, with the pulverizing machine in the stead of the old fire-place.

In discussing the comparative theoretical merits of this method, and grate-burning, some preliminary considerations may be proper. It is necessary to be mindful of the fact that the amount of heat, that is to say the number of units of heat, developed by the complete oxydation of a given quantity of fuel, of a particular constitution, is a constant quantity. It matters not under what circumstances oxydation takes place, whether explosively, as in the case of commingled gases, or by that slow combustion which sometimes requires years to accomplish, the gross amount is always the same. But we are dealing chiefly with *temperatures* in the reverberatory

* It will readily appear that the lambent form of a genuine gas flame is better suited to communicate ignition than the scintillations of specks of fuel, where the flame would have to leap from grain to grain, over an intermediate space of cool or half heated air. It renders ignition more prompt and certain.

furnace—a matter in which quantity of heat is only one of several equally essential conditions, any one of which may be so varied as to occasion the widest variations in temperature. Thus, the increment of temperature produced in a body of gas by the accession of a given quantity of heat, will vary inversely as the volume of that gas—also inversely as the specific heat of the gas. Hence it appears that if we increase the volume of gas (or solid either), through which the heat is to be diffused, we diminish the temperature; or if we impart given quantities of heat to given volumes of gases, the temperatures will vary inversely as the specific heats of the gases. These facts are familiar enough to every student of thermodynamics, and are mentioned merely for the sake of continuity in the argument.

2. For the complete combustion of a fuel of a given constitution, a fixed proportion of air is necessary. When the combustion is complete, we have obtained certain gases, having a definite volume, an average specific heat, and a fixed temperature, which is the maximum temperature which that fuel is capable of imparting. This assumes, of course, that no adventitious heat is added. If an excess of air be supplied, then that excess represents a useless volume, through which the total heat must be distributed, with a consequent lowering of the temperature. If air be deficient, then the fuel will be imperfectly burned, becoming carbonic oxide instead of carbonic acid, and yielding much less heat, with about the same volume of gas, and a consequent lower temperature. We approach the maximum temperature in proportion as we approach the exact proportions of air and fuel necessary for perfect combustion. In common grate burning we depart widely from exactitude in these proportions. At one period we have a grate heaped with fresh fuel, giving off half burned, or wholly unburned, gases; at another, half exhausted coals, coated with ash, to which only a portion of the oxygen can obtain access. The draft, on the other hand, is constant, or only occasionally varied. A stream of air, driven through a bed of ignited coals, first oxidizes the lower layers, converting the carbon it touches into carbonic acid. The latter gas, rising through the bed, takes up more carbon, becoming carbonic oxide, which is, in part, re-oxidized again just above the coals, giving rise to flames. Unless there is a large excess of oxygen, there is a probability that some of the combustible elements of the gases will be unconsumed, owing to imperfect intermixture, and a rapid cooling

below the point necessary to insure ignition by the nearly exhausted oxygen. If hydrogen be present in the form of hydrocarbon vapors, it will, by its stronger affinity, appropriate oxygen, to the exclusion of carbon, and even decompose carbon already oxidized, the latter element passing off in minute flakes, which constitute the dense black smoke always abundantly developed where bituminous or hydrocarbon fuels are burned in an insufficient supply of air. In the puddling furnace these circumstances are more or less modified by admitting a draft over the grate, but the loss of fuel is by no means wholly obviated by this means. In practice, it is usual to drive through the grate at least twice the quantity of air theoretically necessary to oxidize the entire mass of fuel. Indeed, two to one is oftener exceeded than fallen short of. The effect upon the temperature is corresponding, as will appear from the following simple estimates. If a pound of bituminous coal were perfectly burned in a volume of air just sufficient to oxidize all of the combustible elements, the result would be as follows: After deducting the latent heat of vaporization, there would be developed about 1300 units of heat. The resulting gases would occupy (if their temperature were reduced to 60°) 146·6 cubic feet, with an average specific heat of ·26. Their temperature would therefore be $T = \frac{13000}{11{\cdot}22 \times {\cdot}26} + 60° = 4516°$; provided no heat were lost by radiation. If twice the volume of air were used, then $T = \frac{13000}{22{\cdot}44 \times {\cdot}24} + 60 = 2474°$, or a little more than half the temperature under the first supposition. Assuming the air to be fifty per cent. in excess, then $T = \frac{13000}{16{\cdot}83 \times {\cdot}25} + 60 = 3150°$.

Now, it needs but to state the conditions under which pulverized fuel is supplied to the furnace to make it very clear that those conditions are extremely favorable to combustion with a greatly reduced supply of air. We have shown good reason why the enormous excess of 100 per cent. is generally necessary in grate burning. But with pulverized fuel the conditions are radically changed. There, every particle of fuel enters the furnace surrounded by, and in contact with, the very oxygen that is to burn it. The fuel and the air are as perfectly intermixed as possible by the powerful agitation of the pulverizing machine, and at the moment of ignition

the former exposes an enormous surface to the action of the latter. The combustion should therefore be rapid, and very nearly complete, and this without the liability to distil a large portion of gases, or to appropriate carbon from other parts of the fuel less exposed to oxidizing action. Perfect intermixture is essential to perfect combustion. When a current of gas and one of air are brought together, it requires time to mingle them perfectly, and if they are ignited at the junction of the jets, some of the gases will escape combination, though the proportions of each may be exact; for the two are carried forward in eddying currents and whirls, which cannot intermingle until some time after they have cooled down below the temperature of ignition. Hence, we have carbonic oxide, free carbon, oxygen, all escaping from flues and stacks without undergoing combination, and representing so much lost fuel, and adding to the superfluous volume of gases besides. But with pulverized fuel the essential condition of intermixture is vastly improved, so that we seem to approach that perfect intermixture obtained by the transfusion of gases, where atom is in juxtaposition to atom, and we are removed from it only sufficiently to avoid the explosive action attending the contact of flame with perfectly mingled gases. More strictly, the condition of pulverized fuel, sustained in air sufficient to burn it, may be represented by a cube of air $\frac{1}{25}$th of an inch on its edge, holding in its centre a particle of coal.

Now, it is not maintained that these conditions are in their nature such as to insure the perfect combustion of the coal with the theoretical minimum of air, for it is possible to detect circumstances which may, in greater or less degree, interfere with such a result. It must be borne in mind that these particles are not atomic by a very wide interval, and hence their combustion must present the phenomena of progressive absorption of a surface of fuel, and a progressive exhaustion of oxygen; and, as is invariably the case under these circumstances, some minute portions, at least, must escape combustion, unless oxygen be in excess. Then, too, some of the particles are of material size, rendering these phenomena all the more decided. But, on the whole, it certainly seems as though the conditions in question were such that coal, pulverized in the manner described, may be perfectly burned in a supply of air not greatly in excess of the theoretical minimum. At any rate, they are far more favorable in this respect than the best possible method

of grate burning, and probably better than any practical existing method of gas burning.

A prolific source of loss exists in the ordinary reverberatory furnace, which is obviated in great part by Messrs. Whelpley & Storer's method, viz: the loss by radiation from the fire-place. Of the heat generated, only that portion exerts any useful effect which is carried into the hearth. A very sensible amount is lost, however, before the flames enter the hearth. This amount is variously estimated by different investigators, none of whom place it lower than five or six per cent. This need not seem surprising when it is remembered that the area of the surfaces surrounding the fire-place through which heat may be totally lost, amounts to one-third, at least, of that of the hearth itself. Also, at very high temperature heat is radiated and conducted away with a rapidity much greater than that due to a simple ratio of the interior to the exterior temperature. This loss is doubly serious, from the fact that the temperature of the flame, at its hottest point, is inconveniently near to that required in the bath of metal itself. The pulverized fuel furnace, on the other hand, does away almost entirely with the fire-place, and burns its fuel with nearly explosive rapidity, in the hearth itself, avoiding this loss almost completely.

These results may seem surprising to practical men, and yet they may rest assured that they are in perfect conformity with well established facts and principles in physical science. It is not proposed to obtain any more heat out of the combustion of a quantity of coal, but merely an increased temperature from the same quantity by diminishing the volume of gas through which that heat is distributed. We also burn the fuel more completely, and lose less heat by radiation. With this increased temperature we increase the efficiency and rapidity of all operations requiring the acquisition of temperature, and thus shorten the time during which we are compelled to burn the fuel. Let us therefore apply this deduction of increased temperature to the practical management of the reverberatory furnace.

(To be continued.)

ON A SHIP CHANNEL ACROSS CAPE COD.

By Jos. P. Frizell, C. E.

The project of establishing a water communication across Cape Cod, between Barnstable and Buzzard's Bays, thereby cutting off a long stretch of dangerous navigation on an exposed coast, has been before the public at different times for the past one hundred years. The object of this paper is to discuss an important physical and engineering problem, which, arising under precisely similar conditions in no other important work that I am aware of, naturally identifies itself with this enterprise.* The question is this: Should the proposed channel of communication be open to the free flow of the tides, or should the tides be excluded, and the surface of the canal be maintained at an uniform level by means of locks?

To fully appreciate the importance of this question, we must take a preliminary glance at the probable cost of the two methods. By the elaborate and detailed estimate of Mr. George R. Baldwin, contained in his report to a committee of the Massachusetts Legislature in 1862, the total cost of the enterprise, including the artificial harbor in Barnstable Bay, forming a necessary part of the method, was put down at about ten millions of dollars. For the item of excavation, including dredging and land damages, about one million and a quarter was allowed by the most favorable route. In a free channel, excavation would be the principal item. It would, in the aggregate, be considerably greater than in a closed canal, though considerable aid, in this regard, might be expected from the scouring action of the current, as will appear hereafter. Piers or jetties extending into deep waters would also be necessary at the easterly extremity, and perhaps similar structures, though of less magnitude, at the western. By comparison with similar works, I should judge that one million would cover the cost of these solid structures. The works at the Sulina Mouth of the Danube, to be spoken of hereafter, cost about $380,000. It is not essential to the purpose of this paper to go into any exactness with regard to cost.

* The length of the channel will be about eight miles. The period of high tide occurs later in one bay than in the other, the daily maximum variation in height between the two bays being 6½ feet, and the extreme variation nearly 8 feet. Full reports, with plans and diagrams, may be found in *Mass. Pub. Doc.*, No. 41, 1863.

From what precedes, it is apparent that I am safe in saying that the cost of the enterprise by the first named method is less than half, and probably less than one-third, of its cost by the second.

It appears from the report of Mr. Baldwin, above alluded to, that his instructions were "to plan a canal with locks," which is probably his reason for refraining from any discussion of a free channel. The legislative committee, in framing these instructions, probably acted under the advice of the advisory council or board of consultation, consisting of Gen. Totten, chief of the U. S. Engineer Department, Prof. Bache, chief of the U. S. Coast Survey, and Commander Davis, of the Navy. In the Report of these gentlemen, I find only the following paragraph bearing upon this question: "We have already spoken of the locks required in consequence of the different levels of the sea at the two extremities of the canal. The mean of the daily maximum variations in the elevations of the basins is 6·5 feet, and such a fall in the distance of eight miles must, we need not say, be kept under control." It is but reasonable to suppose that a mode of establishing the proposed communication, promising such a vast diminution in the expense, would have been thought worthy of some discussion by this eminent board. The absence of such discussion appears to me to be explainable upon only one theory, viz., the project of a free channel is unique. No example exists, that I am aware of, involving the exact conditions presented here. To arrive at a reliable opinion of its practicability would have required considerable study and research, which the duties of those gentlemen, then very onerous, on account of the war, did not allow them to undertake. They accordingly recommended dispositions which they felt certain would answer the proposed ends, without regard to cost.

The average maximum difference of level* between the two bays is 6·5 feet, or 0·81 feet per mile, though in rare and exceptional instances it amounts to 7·75 feet, or about 12 inches per mile; this state of things, be it remembered, lasting only for some 30 or 40 minutes at the turning of the tide. The first mentioned declivity

* In the report of Mr. Mitchell to the Superintendent of the U. S. Coast Survey, he says: "The mean of the results is 4·66 feet for maximum height of Back River Harbor" (Buzzard's Bay) "above Barnstable Bay, and 5·79 feet for the reverse relations of these basins. Not to underestimate the difficulties of the work, I take the larger figures from the report of the advisory council."—*Mass. Pub. Doc.* No. 41, 1863.

corresponds, for a canal of the dimensions contemplated in Mr. Baldwin's report, to a velocity of about 4·5 feet per second, the second to a velocity of something over 5 feet per second. In calculating the velocity, I make use of the formula established by Humphreys and Abbot.* Such velocities are by no means unusual in navigable channels. The Mississippi at Carrollton, near New Orleans, has a velocity of 5·96 feet per second, at Columbus 6·96 feet per second, at Vicksburg 6·95 feet per second. Bayou Plaquemine, a stream 300 feet wide and 28 feet deep, has a velocity of 5·2 feet per second near its upper mouth. The Rhine at Byland has a velocity of 3·6 feet per second. The Tiber at Rome 3·41.† Bearing in mind that the higher velocity given for the ship channel would only occur at rare intervals, and the lower only once in 12 hours, lasting but 30 or 40 minutes, while the velocities given for the rivers are permanent for periods of high water, it must be conceded that so far as the velocity of the current is concerned, the difference of level will offer no insurmountable obstacle to the navigation of the channel. The transit of vessels would in the aggregate be facilitated by it as much as hindered. Sailing vessels, in particular, would undoubtedly endeavor to take advantage of the tides in passing through.

A much more important question is this: Would the current engendered by the tides act so injuriously upon the bed of the channel as to endanger its navigability? It must be observed here that the velocity in a running stream is proportional to the square root of the head or fall,‡ or, otherwise stated, the fall is proportional to the square of the velocity. The abrasive power of the current is proportional also to the square of the velocity. It follows, then, that the abrasive power is directly proportional to the fall. In an inquiry of this nature, therefore, we must use the mean fall, which is not more than four feet, or six inches to the mile.‖ We need look

* Report on the Physics and Hydraulics of the Miss. River, p. 312.

† *Ibid.* 316.

‡ It is so assumed by the majority of the Hydraulic writers, though most formulæ deviate slightly from this supposition, not enough, however, to affect the truth of my conclusion.

‖ The advisory council say, in continuation of the remark previously quoted from their report: "We might have given here the extreme difference, 8 feet; for it must be observed that this is a case in which *extreme* and not *means* enter into the argument." The extreme head can only enter into the argument here, with reference to structures designed to control the tide, i. e. to locks, since such structures must be strong enough to resist the greatest force that they can ever be

for no greater abrasion here than would take place in any alluvial stream of equal cross-section, with a declivity of six inches to the mile. That rapid erosions of the bed and great shifting of material would take place in a channel exposed to such a declivity, there can be no doubt, but, by comparison with the great water courses alluded to above, I do not find any reason to doubt the preservation of a sufficient depth. The Mississippi, at Carrollton, Vicksburg and Columbus, with a velocity of 6 or 7 feet per second, maintains a high water depth of from 88 to 136 feet. The Rhine at Byland, with a velocity of 3·57 feet per second, has a depth of 20 feet. The Neva in Russia with a velocity of 3·23 feet per second has a depth of 50 feet.* The Mississippi, in six days of high water, carries past Carrollton a quantity of solid material equal to the entire excavation of this channel.† How happens it, then, that the channel of the river does not fill up at this point? Because it is as impossible for material to be deposited in a strong current as to be taken up by a weak one. *A strong current and great volume of water are the surest guarantees of a sufficient depth.*

The bayous of the Lower Mississippi are natural water courses, existing under circumstances very similar to those of the proposed channel. Leading from the main channel of the Mississippi into the Gulf, they flow sometimes with a violent, sometimes with a very gentle current, according to the stand of the river. It not unfrequently happens that some of them, when the river is low, and the surface of the Gulf is raised by northerly winds, flow in the opposite direction, discharging salt water into the Mississippi. Yet these channels exhibit a remarkable tendency to preserve and even to increase their depth. Bayou Plaquemine has a maximum depth of 24 to 28 feet, Bayou La Fourche 23 to 27 feet. The latter is an important channel of inland communication, although no attempt, so far as I am aware, has ever been made to improve or maintain

---

exposed to. When we come, however, to speak of the aggregate work of abrasion performed by the current, or the aggregate resistance to vessels occasioned by it, it is obviously not the extreme nor the average maximum, but the actual average head, that enters into the argument. This reasoning of the council, when analyzed, is a little curious. The necessity for assuming an extreme head rests upon the supposed necessity for locks. The necessity for locks rests upon the assumption of an extreme head.

* Report on Phys. and Hyd., &c., p. 316.

† *Ibid.*, pp. 148, 150.

its navigability by artificial means. The former, being of short length, and not forming a link in any important route, is not much used for that purpose. Messrs. Humphreys and Abbott* say: "Bayou La Fourche, the last of the outlets of the Mississippi, in many respects resembles an artificial canal. Its current does not exceed three feet per second, its bends are few in number and gentle in curvature. There are no boils, whirls or eddies, nor are the banks abraded to any perceptible extent. * * * Its width between the natural banks averages about 230 feet and undergoes but little variation."

There is a class of artificial channels which bear a still more striking analogy to this work, viz: cut-offs, occurring at great bends of rivers. This channel would simply be a cut-off in tidal waters. Several operations of this kind have been executed upon the Mississippi, in some cases shortening the navigable channel more than twenty miles. The declivity in such streams is sometimes very great, the entire fall in a long channel of the river being concentrated in the short channel of the cut-off. The fall through Raccourci cut-off in the flood of 1851 and also of 1858 was 7 inches per mile.† This is greater than the effective fall (as regards abrasive power) in the C. C. channel, yet these cut-offs are daily traversed by deep laden steamers, and no engineer that I am aware of ever suggested the use of locks at these localities. They sometimes occur spontaneously, and in all cases the erosive power of the current is the chief agent in their formation.

A great number of these works have been executed upon the Rhine.‡ Between Neuberg and the Hessian boundary there are no less than 75 miles of cut-offs, the number being 17. They are usually excavated artificially, deep and wide enough to let in the current in sufficient volume to be effective, and, in the majority of cases, in from one to four years, become navigable for the vessels that frequent the Rhine Stream. Taking the average of all these channels, the fall per mile is greater than the effective fall in the C. C. ship channel.

I have endeavored, thus far, to illustrate the workings of the proposed channel by reference to streams flowing permanently in

* Report on Phys. & Hyd. &c., p. 423.

† Report on Phys. and Hyd., &c., p. 375.

‡ Hagar. Handbuch der Wasserbaukunst, Zweiter Theil. Die Ströme, 2d Vol. p. 115. *et seq.*

one direction. To anticipate all the objections that may be urged against my views, it may be necessary to instance channels whose depth is maintained by tidal currents.

A glance at the chart of the Hudson is instructive in this connection. The river presents a broad and deep channel from the mouth nearly up to Albany, or just so far as the tide is effective in producing strong currents. The point where this influence ceases marks the transition from a broad and deep channel to a shallow, tortuous and difficult one.

The improvements now being executed in the upper portion of this river consist mainly of dispositions intended to increase the current, such as dykes cutting off unnecessary expanses of the water, closure of chutes, &c., the object being to create a greater velocity and force the current to take up a greater amount of sediment. Dredging is resorted to only where the application of this method would be too expensive. One reflection is important here. Is it not to be feared that the material taken up where the current is artificially increased will be deposited in the lower reaches of the stream to the detriment of navigation? No trouble, so far as I can learn, exists or is apprehended from this cause. The material once brought within the range of the strong currents due to the tides, cannot remain permanently deposited in the channels. For the same reason, in a free channel across the Cape no apprehension need be felt that material excavated at one part of the channel will be deposited in another, to the injury of navigation, so long as a general uniformity of cross section is preserved. Material once taken up by the current is held in suspension until the velocity of the current abates, and cannot be permanently deposited except at the outlets where the effluent current is brought to rest.

The East River, between New York city and Long Island, is one of the many instances that might be named of a channel kept open by tidal currents.

(To be continued.)

ON A NEW MACHINE FOR PRODUCING TRUE CYLINDRICAL SURFACES.

By J. Morton Poole.

Late in the year 1866, application was made to the firm of which the writer is a member, by Jessup & Moore, of Philadelphia, to construct for them a stack of the rolls used in their business for calendering paper. The stack in question was to be composed of nine rolls, eighty-four inches wide on the face, and varying in diameter from six to fifteen inches. The problem to be solved was to construct this calender with such accuracy that when the nine rolls composing it were placed in position, one above the other, the line of contact between any two adjoining rolls would be so perfect as not to allow light to pass through.

Two approximate ways of effecting this object were in use. The most common was to turn the rolls as true as could be done in a lathe, then to place them in stands similar to those in which they worked when in use, cause the surfaces in contact to run in contrary directions and smear them plentifully with oil and emery, at the same time giving the rolls a slight motion of translation to prevent their wearing in ridges.

The other method was to use a revolving metal lap with emery and oil, verifying the work as it progressed with straight-edge and calipers, setting the rolls in position, marking the high places, grinding and marking again, and so on approximating toward perfection.

Both of these processes produced very unsatisfactory results, and as the writer had in use in his business machinery on a small scale for grinding with an emery wheel, he designed a machine to use this method of grinding, on a scale sufficiently large to grind the large rolls called for in the stack. The drawings were completed and the patterns partly made, when the conviction before felt became more strong with him, that to depend for the accuracy of results upon the accuracy of the ways of a grinding machine, which, however straight they might be at first, would soon lose their truth by the natural wear of one part moving on another, would only result in disappointment. At this juncture there flashed upon his mind the true principle whereby perfection would be obtained without regard to the perfection of the ways of the machine, and

he hastened to destroy his patterns and drawings and to start afresh, the result being the machine we are about to describe.

In the illustration, E represents the bed, which is constructed somewhat like the bed of a planing machine. D is a saddle, which slides in the ways on the bed. Suspended to this saddle and above it, by the links F F, is a second saddle, C, which carries two grinding wheels, B B. These wheels are capable of separate adjustment to grind rolls of different diameters. A represents the roll to be ground. The links supporting the saddle, C, rest on knife edges, and every effort is made to reduce the friction, so that the least possible force is required to cause the saddle to vibrate. The saddle C is also made exceedingly strong and heavy, both to resist any possible spring and also to have sufficient gravity to resist the pull of the driving belts. An arrangement is provided whereby any amount of friction may be put on the vibration of the saddle, even to the extent of locking it fast and preventing its vibration entirely. Now, it is evident that if the ways on which the saddle D slides were perfectly straight, the axis of the roll A placed perfectly parallel with the line of motion, the saddles C and D locked together, and the machine set in motion, that the cylinder produced by grinding would have the same perfection as the ways on which the rest travels. That this is impracticable we have before shown. It is also an impossibility to set the axis of the roll A perfectly parallel with the line of motion of the rest; there will always be some little want of parallelism, the effect of which would be to make the cylinder a frustum of a cone.

To illustrate the manner in which the accuracy of results obtained is quite independent of the accuracy of the ways, or want of parallelism between ways and axis of roll, we will assume that the ways of our machine are curved, or irregular in form, so that with our saddles locked together, and the roll ground with a single

grinder, the outline of the roll would be an exact copy of the irregularities of the bed. Consider the roll A as having been ground in this way, so that every part revolves truly.

We now relax our friction arrangement, so that the upper saddle is perfectly free to swing transversely.

Now, the effect of this curved or irregular form of the ways would be, as the rest traverses, to force one grinding wheel against the roll and the other away from it, but the saddle C being free to move transversely, yields the moment the pressure of the two grinding wheels on the roll would tend to become unequal, or rather the upper saddle remains stationary, both grinders bearing on the roll with the same force, and allows the lower saddle to move beneath it as it follows the irregularities of the bed. It is evident that these two grinding wheels, once adjusted on their saddle, the distance between them cannot vary; and that if they can be traversed from end to end of a roll without a reduction in their diameter, the roll revolving truly and both grinding wheels bearing on the roll with the same force, that the diameter of the roll must be the exact distance between the circumference of the grinding wheels, and consequently uniform. As all these requirements are fulfilled in the machine just described, it is evident it cannot do otherwise than produce a perfect cylinder, which problem it, for the first time, solves, and solves too in a manner far more expeditious than by any of the imperfect and approximate methods before mentioned. Supplying as it does a want which has been much felt, it has not failed to be appreciated, and in the purpose for which it was originally designed, that of grinding paper makers' calenders, it has nearly superseded any other method.

The heavy chilled rolls used in the rubber manufacture and in that of brass, copper, sheet iron, &c., have also been ground by this principle, and always to the manifest improvement of their products.

The above description serves to give a general idea of the principle upon which this machine depends for the accuracy of its work. There were, of course, many details to work out, and much knowledge to be gained before this principle could be reduced to practice. The first great difficulty was with the grinding wheels themselves, and their perfection cost more time, labor and expense than any other part of the machine. When it is considered that these wheels are required to traverse from end to end of a roll sometimes

as long as eight feet, without perceptible wear or diminution in diameter, it will be seen what a difficult matter it becomes, and yet one that it was necessary to accomplish before the machine was a practical success.

Another point early developed was the impossibility of grinding a cylinder true without it was kept at an uniform temperature by the application of a plentiful stream of water. The attempt was first made to grind dry, but it was found that if the rolls were ground true and allowed to cool, they were as much out of truth as at the beginning of the operation. It was also found that the greatest care was requisite to have the journals on which the roll revolved during the grinding operation, ground till they were truly round. With bearings *not* round, in grinding with a single grinder the outline of the roll will be a copy of the irregularities of the bearing; but with wheels on each side there is a constant strife between them to change the outline of the roll, which renders it quite impossible to grind it to any degree of truth. It will thus be seen that the two wheels act as a check upon the roundness of the bearings, which have consequently to be ground themselves on dead centres till they are perfectly round and true.

The principle of this machine has also been applied to grinding the rolls of curved outline required in the sheet iron manufacture. These are of such a form that when heated by the operation of rolling they are straight. This necessitates their being smaller in the middle, and they are ground by placing the roll in the machine in such a position that in the middle of its length its axis and the axes of the two grinding wheels are in the same straight line, and one end of the roll is elevated a certain distance above the axis of the grinding wheels, and the other end depressed a corresponding distance below. The result is that the curve required is ground with great exactness, and may be varied to any amount of concavity by elevating and depressing the ends of the roll more or less.

In conclusion, we would say that the principle upon which this grinding machine works being a perfect one, its work can only vary from the truth by reason of mechanical defects or deficiencies. For example, the wear of the grinding wheels in passing across the roll would have the effect of grinding a frustum of a cone. There must be *some* wear—how inappreciably little it must be, and how near perfection are the rolls ground by this process, will be seen when we say that two rolls gently pressed in contact, with an end-long movement given to one, will produce a continuous burnished line on each from end to end, and that the rolls composing a stack may be arranged in the thousands of ways in which a number of rolls may be combined, and they will still coincide and touch each other throughout the whole length.

FORMULÆ, RULES AND EXAMPLES OF COMPUTATION FOR SOME OF THE MOST USEFUL CASES OF EARTHWORK UNDER WARPED AND PLANE SURFACES.

By John Warner, A. M.

Object proposed.—I shall here present a number of formulæ which, it is believed, will be found useful in practice and interesting for their form and mode of derivation.

*Definition of the Ground Surface:—Straight Work.**—Intending, on a future occasion, to treat more at length of the ground surface, I shall here only define it as assumed for the present investigation, and omit extended remarks on the practical sufficiency or utility of the formulæ. The ground surface is assumed to consist of one or more hyperbolic paraboloidal surfaces generated by the motion of straight lines always parallel to the vertical end planes of the work, and moving lengthwise of it upon straight directrices. The external straight bounding lines of the surface, which connect the outside corners of the work, are always supposed to be directrices, and the straight surface line connecting the extremities of the centre heights at opposite ends of the work is always taken for a directrix when this line is supposed to exist. Other straight directrices may be imagined to extend from points on the surface line of one of the end cross-sections to points upon the surface line of the other; but in all cases no two directrices must cut the same longitudinal vertical plane within the limits of the work. The two end cross-sections and the mid cross-section of a piece of so-called *three-level* ground may be represented, in their general features, by the annexed diagrams, which refer to excavation but will serve to explain

* The discussion of curved work is here omitted.

embankment by imagining the diagrams inverted. They will be understood without minute explanation. The surface lines F B, F C, on any cross-section of three-level ground are supposed to be straight; these are the generating lines of the ground surface, which move upon straight directrices passing through B B, F F, C C. The line B F C may either be broken in F or be a continuous straight line, according to the relative dimensions of the cross-section under consideration. If B F C is a broken line on any one cross-section, the ground surface will be divided into two portions, one on the right the other on the left of the centre; either or both of which portions may be warped or plane. In like manner each of these portions of the surface may be again subdivided, and so on, as long as the inequalities of the surface lines of the end cross-sections require this mode of subdivision. If the lines F B, F C, form a continuous straight line on each of the end cross-sections, the ground surface if not plane may, according to the judgment of the computer, be considered either as a single warped surface having everywhere the straight surface line B C, or the surface line B C may be considered as broken at F on all cross-sections except those of the ends. When the surface is a plane, both these hypotheses merge into one.

Of the other Bounding Surfaces.—These are generally plane in practice. The present paper treats the roadbed and the end surfaces as necessarily plane; the side slopes are not always considered necessarily plane, nor their inclinations necessarily equal.

Given Dimensions include the length of the work, the centre and side heights, distances, width of roadbed, and angles of side slope; but all these are not necessary in every case.

Notation.—It will perhaps be more convenient to exhibit this collectively than scattered through the paper, in order that the reader may refer to it as occasion requires.

L = length of the work perpendicular to the cross-sections.
B = width of roadbed.
h = centre height G F.
H = centre height A F, from the intersection of the side slopes, on the mid cross-section.
H′ = centre height A F on the first end cross-section.
H″ = centre height A F on the second end cross-section.

H, H′, H″ are called augmented centre heights.

G = twice G A, or the double augment of the centre height; G A is called the augment of the centre height.

β = whole width or total base M N on the mid cross-section.

β' = total base M N on the first end cross-section.

β'' = total base M N and the second end cross-section.

σ = angle of side slope B D H or B A M.

σ' = angle of side slope C E Q or C A N.

$\frac{1}{2}d$ = G G′, the distance of a point on the roadbed from the centre.

S_h = sum of the end centre heights G F.

D_h = difference of the same.

S_H = sum of the augmented end centre heights A F, or augmented sum of centre heights = $H' + H''$.

D_H = difference of the same = $H' - H''$.

S_b = sum of total bases H Q or M N at the ends = $\beta' + \beta''$.

D_b = difference of the same = $\beta' - \beta''$.

S'_b = sum of the half end widths G D or G E of roadbed = B when the width is uniform.

D'_b = difference of the same = 0 when the width is uniform.

S'_h = sum of all the four side heights B H, C Q; B H + C Q may be called the total side height of a cross-section.

D'_h = difference of total side heights at the ends.

S''_h = sum of the end side heights B H.

D''_h = difference of the same.

S'''_h = sum of the end side heights C Q.

D'''_h = difference of the same.

S''_H = sum of the augmented end side heights B M.

D''_H = difference of the same.

S'''_H = sum of augmented end side heights C N.

D'''_H = difference of the same.

S''_d = sum of end distances out G H or A M.

D''_d = difference of the same.

S'''_d = sum of end distances out G Q or A N.

D'''_d = difference of the same.

S^{iv}_d = sum of the marginal distances out D H at the ends.

D^{iv}_d = difference of the same.

S^{v}_d = sum of marginal distances out E Q at the ends.

D^{v}_d = difference of the same.

S_m = sum of the end side slopes A B.

D_m = difference of the same.

S_n = sum of the end side slopes A C.

D_n = difference of the same.
A = area of mid cross-section.
A' = area of first end cross-section.
A'' = area of second end cross-section.
V = volume.
V_p = volume of the redundant prism on A D E.
V_s = volume contained between the ground surface and intersection of side slopes.
V_w = volume of the work.

Dimensions of the several Cross-sections.—The mid cross-section is an hypothetical one, having each of its linear dimensions and the auxilliary lines of its diagram, respectively, the mean between the like parts on the diagrams of the ends. The lines of the end cross-sections will be found by adding to or subtracting from the mean dimensions of the mid cross-section, respectively, the half difference of the like end dimensions. Before deriving these expressions we will remark that the differences of the end dimensions may, in the formulas, all be regarded as positive in relation to either one of the end cross-sections, but that in the application of the formulæ, we must give each difference its proper sign, in order to know the sign of the *product* of the differences. This is equivalent to considering the differences to be of like sign and their product positive if, on the end cross-section chosen, the greater height is coupled with the greater base; otherwise the product is negative.

For the mid Cross-section:—

$$G F = \tfrac{1}{2} S_h \qquad C Q + B H = \tfrac{1}{2} S'_h \qquad A B = \tfrac{1}{2} S_m$$
$$H Q = \tfrac{1}{2} S_b \qquad G E = \tfrac{1}{2} S'_b \qquad A C = \tfrac{1}{2} S_n$$

For the first end Cross-section:—

$$G F = \tfrac{1}{2}(S_h + D_h),\ C Q + B H = \tfrac{1}{2}(S'_h + D'_h),\ A B = \tfrac{1}{2}(S_m + D_m)$$
$$H Q = \tfrac{1}{2}(S_b + D_b),\ G E = \tfrac{1}{2}(S'_b + D'_b),\ A N = \tfrac{1}{2}(S_n + D_n)$$

For the second end Cross-section:—

$$G F = \tfrac{1}{2}(S_h - D_h),\ C Q + B H = \tfrac{1}{2}(S'_h - D'_h),\ A B = \tfrac{1}{2}(S_m - D_m)$$
$$H Q = \tfrac{1}{2}(S_b - D_b),\ G E = \tfrac{1}{2}(S'_b - D'_b)\ A N = \tfrac{1}{2}(S_n - D_n)$$

We may also here note the following values:—

$$S_m = S''_{II} \operatorname{cosec} \sigma = S''_{II} \frac{1}{\sin. \sigma'} = S''_d \operatorname{sec}. \sigma = S''_d \frac{1}{\cos. \sigma'}.$$

$$D_m = D''_H \operatorname{cosec} \sigma = D''_H \frac{1}{\sin. \sigma} = D''_d \sec. \sigma = D''_d \frac{1}{\cos. \sigma}.$$

$$S_n = S'''_H \operatorname{cosec} \sigma' = S'''_H \frac{1}{\sin. \sigma} = S'''_d \sec. \sigma' = S'''_d \frac{1}{\cos. \sigma}.$$

$$D_n = D'''_H \operatorname{cosec} \sigma' = D'''_H \frac{1}{\sin. \sigma'} = D'''_d \sec. \sigma' = D'''_d \frac{1}{\cos. \sigma'}.$$

$$S_m = (S''_h + G) \operatorname{cosec} \sigma = (S''_h + G) \frac{1}{\sin. \sigma}.$$

$$D_m = D''_h \operatorname{cosec} \sigma = D''_h \frac{1}{\sin. \sigma}.$$

$$S_n = (S'''_h + G) \operatorname{cosec} \sigma' = (S'''_h + G) \frac{1}{\sin. \sigma'}.$$

$$D_n = D'''_h \operatorname{cosec} \sigma' = D'''_h \frac{1}{\sin. \sigma'}.$$

These values of S_m, S_n, D_m, D_n, do not change their form if we suppose the angles of side slope to be unequal, and hence the vertical line A F to cut the roadbed out of the centre, as at G′. But in the case of unequal angles of side slope, put $G G' = \frac{1}{2} d$, and consider it positive when B A M is less than C A N, and negative in the opposite case. We shall then find the following values, which will also hold for equal angles of side slope by putting $d = 0$.

$$D G' = D G + G G' = \tfrac{1}{2} (B + d); \quad G' E = G E - G G' = \tfrac{1}{2} (B - d).$$

$$S_m = (S^{iv}_d + B + d) \sec \sigma = (S^{iv}_d + B + d) \frac{1}{\cos. \sigma}.$$

$$D_m = D^{iv}_d \sec. \sigma = D^{iv}_d \frac{1}{\cos. \sigma}.$$

$$S_n = (S^{v}_d + B - d) \sec. \sigma' = (S^{v}_d + B - d) \frac{1}{\cos. \sigma'}.$$

$$D_n = D^{v}_d \sec. \sigma' = D^{v}_d \frac{1}{\cos. \sigma'}.$$

(To be continued.)

AN EXAMINATION OF SOME EXPERIMENTAL FACTS BEARING UPON THE PROPER RATIO OF THE LENGTH AND BREADTH OF STEAMSHIPS.

By Alban C. Stimers, Naval Engineer.

(Concluded from page 309.)

In the following table the foregoing mean ratios of length to breadth are employed in the same manner as before to obtain the per centum of displacement required for the longitudinal iron of the hulls.

a. Class.	b. Ratio of L to B.	c. L.	d. B.	e. D.	f. Surface.	g. Comparative Surface	h. Comparative L to D.	k. Comparative weights of Long. Iron	m. Per cent. of Displacem't of long. iron
Example.	6·33	6·333	1·000	0·600	14·0277	1·00000	1·00000	1·00000	18·40
A	3·38	4·167	1·233	0·740	11·5687	0·82470	0·53368	0·44012	8·10
B	4·15	4·777	1·151	0·691	12·3021	0·87699	0·65526	0·57465	10·57
C	4·71	5·199	1·104	0·662	12·7771	0·91085	0·74368	0·67738	12·46
D	5·71	5·911	1·035	0·621	13·5761	0·96786	0·90158	0·87260	16·06
E	6·98	6·757	0·968	0·581	14·4727	1·03172	1·10210	1·13761	20·92

Adding 3 per centum for *transverse stiffening* and 15 per centum for *equipments* in the same manner as before, and we have for the total weights of vessel, exclusive of machinery, coals and cargo, the following:—

Class A	26·10	per centum of the displacement.			
" B	28·57	"	"	"	"
" C	30·46	"	"	"	"
" D	34·06	"	"	"	"
" E	38·92	"	"	"	"

These weights of vessel are taken in connection with the coefficients of performance of each class as before to determine the actual displacements, powers and weights of steam machinery and weights of coals necessary in each case to carry 3,000 tons of cargo a distance of 3,000 miles in ten days. The results are given in the following table:—

Class	Coefficient of Performance.	Weight of Cargo.	Weight of Hull and Equipments.	Weight of Steam Machinery.	Weight of Coals.	Mean Displacem't.	Horse Power.	Cost of Hull and Equipments.	Cost of Steam Machinery.	Total Cost.
		Tons.	Tons.	Tons.	Tons.	Tons.		$	$	$
A	159·2	3,000	1,416	379	1,262	5,426	3,788	354,000	151,520	505,520
B	181·1	3,000	1,504	334	1,112	5,442	3,336	388,500	133,440	521,940
C	197·9	3,000	1,674	307	1,024	5,493	3,072	418,500	122,880	541,380
D	198·1	3,000	1,990	320	1,078	5,844	3,199	497,500	127,960	625,460
E	252·4	3,000	2,347	256	854	6,030	2,564	586,750	102,560	689,310

Let the annual expense of capital be 32 per cent., and the coal account represent eight round trips per annum with coal at $6 per ton in the bunkers as before; and we have the comparative annual expense in the following table:—

Class.	A.	B.	C.	D.	E.
	$	$	$	$	$
Annual expense of capital	161,766	167,021	173,242	200,147	220,579
Annual expense of coals.....	121,152	106,752	98,304	103,488	81,984
Total of the variable expenses...	282,918	273,773	271,546	303,635	302,563

Again assuming the gross earnings of each ship per annum at $360,000 above the unenumerated expenses and the *net* earnings will be as follows:—

Class A.....	$77,082
" B.....	86,227
" C.....	88,454
" D.....	56,365
" E.....	57,437

And the per centa which these sums bear to the first cost of the ships, or, in other words, to the amount of capital invested, are as follows:—

Class A.	15·25
" B.....	16·52
" C.....	16·84
" D.....	9·01
" E.....	8·33

Again, the ratio of four lengths to one breadth proves a better proportion for earning large dividends upon the capital invested than any higher ratio; but again, the difference between this and the ratio of 5 to 1 is essentially nothing, being only 0·18 of one per cent. The excess over the ratio of 3·38 to 1 is only 0·77 of one per cent., while over that of 5·71, or say 6 to 1, it is 7·51 per cent., and over that of 7 to 1 it is 8·19 per cent.

It might be claimed that we would get more satisfactory results if we were to select from each class, the vessel which shows the best coefficient of performance. I have, therefore, done this, and give the particulars in the following table:—

Class	Names of Vessels.	Ratios of Length to Breadth.	Speed in Knots per hour.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$
A	Lion.....	3·37 to 1	9·529	196·2
B	London.....	3·96 to 1	9·508	208·6
C	Resistance.....	5·18 to 1	10·372	245·7
D	Miranda...	5·77 to 1	10·750	247·5
E	Himalaya.....	7·38 to 1	12·900	297·4

In the following table the above ratios of length to breadth are employed in the same manner as heretofore to obtain the proportion which the weight of the longitudinal iron bears to the displacement.

a. Class.	b. Ratios of L to B.	c. L.	d. B.	e. D.	f. Surface.	g. Comparative Surface.	h. Comparative L. to D.	k. Comparative weights of Long. Iron.	m. Per ct. of Displacement of Long. Iron.
Example	6·33	6·333	1.000	0·600	14·0277	1·00000	1·00000	1·00000	18·40
A	3·37	4·159	1·234	0·740	11·5550	0·82373	0·53240	0·43860	8·05
B	3·96	4·631	1·169	0·702	12·1178	0·86385	0·62385	0·53891	9·92
C	5·18	5·539	1·069	0·642	13·1612	0·91687	0·81789	0·74990	13·80
D	5·77	5·952	1·032	0·619	13·6171	0·97074	0·91105	0·88439	16·27
E	7·38	7·013	0·950	0·570	14·7329	1·05027	1·16526	1·22384	22·52

Adding to the quantities in column m, the 3 per cent. for *transverse stiffening* and 15 per cent for *equipments* in the same manner as heretofore and we have the following:—

Class A	26·05	per centum of the displacement.
" B	27·92	" " " "
" C	31·80	" " " "
" D	34·27	" " " "
" E	40·52	" " " "

These weights and the coefficients of performance of each class in this case are employed as heretofore in the following table:

Class.	Coefficient of Performance.	Weight of Cargo.	Weight of Hull and Equipments.	Wt of Steam Machinery.	Wt of Coals.	Mean Displacement.	Horse Power.	Cost of Hull and Equipments.	Cost of Steam Machinery.	Total Cost.
		Tons.	Tons.	Tons.	Tons.	Tons.		$	$	$
A	196·2	3,000	1,335	296	986	5,124	2,958	338,750	118,320	452,070
B	208·6	3,000	1,452	281	936	2,201	2,810	363,000	112,400	475,400
C	245·7	3,000	1,701	244	810	5,350	2,432	425,250	97,280	522,530
D	247·5	3,000	1,909	248	826	5,570	2,480	477,250	99,200	576,450
E	297·4	3,000	2,440	217	724	6,019	2,173	610,000	86,920	696,920

Assuming the annual expenses for capital and for coals at the same rates as heretofore, and we have the results in the following table:—

Class.	A.	B.	C.	D.	E.
	$	$	$	$	$
Annual expense of capital	144,662	152,128	167,201	184,474	228,020
Annual expense of coals	94,656	89,856	77,760	79,296	69,504
Total of the variable expenses	239,318	241,984	234,961	263,770	292,524

With the gross earnings the same as has been heretofore assumed the *net* earnings will be as follows:

Class A	$120,682
" B	118,016
" C	125,039
" D	96,230
" E	67,476

And the per centa which these bear to the first cost of the ships are as follows:—

Class A	26·70
" B	24·82
" C	23·93
" D	16·69
" E	9·68

Here the ratio of $3\frac{3}{4}$ lengths to 1 breadth is the superior proportion for earning money on a transatlantic voyage. It will pay 1·88 per cent. better dividends than the ratio of 4 to 1; 2·77 per cent. better than 5 to 1; 10 per cent. better than 6 to 1, and 17 per cent. better than $7\frac{1}{2}$ to 1.

When a capitalist invests money in a steamship enterprise he does so for the purpose of making such capital productive. There is no advantage to him in achieving a high coefficient of engineering performance unless there is connected with it a correspondingly high rate of dividends. In this country it is also an advanaage in favor of any peculiarities of the steamship if they reduce the amount of capital required to inaugurate the desired undertaking.

In the following table is stated the advadtages and disadvantages in these respects of the various proportions of length to breadth just examined as developed by the trials at the measured mile of English naval screw steamers.

Class.	Ratio of L. to B.	Comparative amount of capital required, according to			Annual Dividends earned when longest vessels pay expenses only, according to		
		Means of all the Vessels.	Means of better half of vessels.	Best vessel in each class.	Means of all the vessels.	Means of better half of vessels.	Best vessel in each class.
A.	$3\frac{3}{4}$ to 1	75	73	65	4 per cent.	7 per cent.	17 per cent.
B.	4 to 1	75	76	68	8 " "	8 " "	15 " "
C.	5 to 1	80	79	75	7 " "	8 " "	14 " "
D.	6 to 1	90	91	83	2 " "	1 " "	7 " "
E.	7 to 1	100	100	100	0 " "	0 " "	0 " "

In choosing the proportion which should be given to a proposed transatlantic steamer, the above table would indicate that of 4 to 1 as being the most profitable, the rate of dividends being a little higher than that of 5 to 1, but the difference is very slight, and in every case the absolute net earnings are the greatest with the proportion of 5 to 1, whence the dividends would be greatest with that proportion under circumstances which reduced the earnings to the expenses of the shorter ships.

The lesson which this investigation of these trials teaches is, therefore, I think, clearly in favor of giving transatlantic steamers the proportion of 5 lengths to 1 breadth.

Mechanics, Physics, and Chemistry.

NOTES ON CRYSTALLOGRAPHY.

By W. H. Wahl.

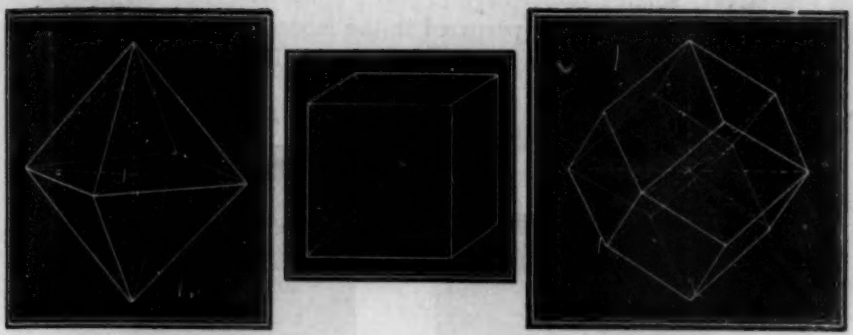
A CRYSTALLOGRAPHIC SYSTEM is well defined as the assemblage of all the simple forms built upon the same law of symmetry, and of all the possible combinations of these forms with each other.

In previous papers it was noticed that if a comparison was instituted between the axial crosses of different crystals, they would be found to differ essentially from each other. If these differences are carefully studied, one cannot fail to be impressed with the fact that they are deep seated, and that they are the infallible indicators of characteristic pecularities in the internal structure of crystals; peculiarities which affect in a remarkable degree their so-called physical properties. The behavior of the individual towards light, heat and electricity; the relative hardness, lustre and tenacity of its parts seem to be absolutely dependent upon the character of the axial framework about which it is built up.

It is clear, therefore, that if a rational classification of crystals can be instituted, based upon their axial resemblances and dissimilarities, the clue has been found which will guide the student from the labyrinth of confusion into which the contemplation of an almost infinite variety of form has placed him. It will be no barren labor, but one well calculated to impress the mind of the novice with surprise and pleasure, to delve into this labyrinth and to find how readily complexity resolves itself into simplicity—to find in forms totally unlike and to all appearances totally unrelated, the same law of symmetry, simple and unmistakable, uniting them.

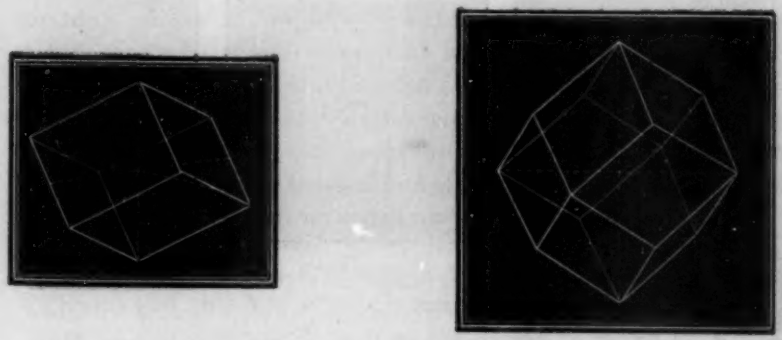
Crystallographers do not construct for each crystal all the *possible* axes in explaining its properties and relations. Such a procedure would render hopeless indeed any attempt at classification, as a momentary inspection of the accompanying figures will show. The figures here represented are known as the Octohedron, Hexahedron (cube), and Dodecahedron respectively. As will hereafter be shown, these forms bear to each other a close relationship; but we should seek this relationship in vain if, for instance, the angles

Fig. 1. Fig. 2. Fig. 3.



were taken as the points of departure, and the axes were assumed as joining them. With the Octohedron, then, we should find three, with the Hexahedron four, and with the Dodecahedron seven axes, and these axial systems differ from each other not only as regards number, but also in their mutual inclination and length, and the conclusion we should be warranted in asserting from such premises would be, that the forms in question were wholly unrelated; a conclusion quite at variance with that announced above. Without entering further into the details of similar comparisons, which might be multiplied at pleasure, it may be stated that the most exhaustive study of many forms has led to the belief that a cross of

Fig. 4. Fig. 5.



three, or at most of four lines uniting certain terminal parts constitutes the true framework about which the parts have been located with more or less symmetry. By far the greater number of crystals

are analyzed by three such imaginary lines, while but a comparatively small number require four; none, however, have as yet been found in nature or prepared in the laboratory which required more than four axes for its complete elucidation.

Fig. 6.

Fig. 7.

A glance at the preceding figures will show some forms with three and with four axes.

Here, then, we have obviously before us one of those axial differences so pregnant with importance in originating those physical peculiarities previously alluded to. Whether or not this alone is sufficient to account for all the physical characteristics presented by

Fig. 9.

Fig. 8.

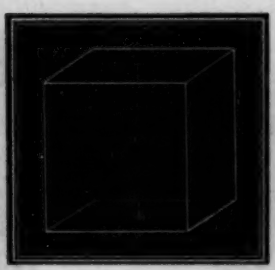


Fig. 10.

various crystals, is a query which can only be answered upon further analysis. An inspection of several crystallized minerals may answer it. Orthoclase, Dichroite and Rock-salt are three minerals

crystallizing in forms which, so far as the *number* of their respective axial systems is concerned, are identical; each individual has three axes, but as regards their physical properties, these minerals stand strongly contrasted. The crystal of the last named may be cleaved with equal perfection in three directions, corresponding to the direction of the axes, the lustre of each of the faces is the same, and the light or heat rays in their passage through the crystal in any direction are similarly affected. The individual of the second mineral, by its peculiar action upon the light which it transmits reveals a complete difference in its internal structure from the one just considered. The light which reaches the eye after passing through it in the direction of one of the axes, is blue, while that which passes in the direction of either of the others is yellowish.

With Orthoclase, we have a cleavage nearly perfect in the direction of one of the axes, less perfect in another, while in the third, it is nearly, if not altogether wanting. The lustre of its surfaces also is not the same, certain ones having the appearance of mother of pearl, others the strong, even lustre of glass—properties strikingly different from the behavior of rock salt.

Here, then, we have examples—they might be duplicated by the score—which clearly indicate that the characteristics of crystals are but imperfectly accounted for, in the classification thus far established; which, as will be remembered, is a classification based simply upon the number of the axes.

If the crystals just instanced are subjected to a closer scrutiny, we shall not fail to bring to light certain differences in these apparently identical axial systems upon which important functions depend, and to which the unconformable behavior of our examples may unhesitatingly be referred. Instituting the comparison between the crystals of Rocksalt and Dichroite—a difference in the relative lengths of the axes in each will be observed—with the first, all the axes are equal in length; with the second all the axes are unequal. In every other respect the framework of these substances is identical; with both, the axes are three in number and intersect at right angles. Upon this difference, therefore, in the relative lengths of their axes, the peculiar behavior of the minerals, Rocksalt and Dichroite, in relation to the perfection with which they cleave in different directions, and their action upon the character of the light or heat they transmit, must depend. Between the individual of Rocksalt and Orthoclase the same dissimilarity exists as we have found

between the first and Dichroite, affording, if it were desired, a substantiation of the proposition just asserted. By comparing together the crystal of Dichroite and Orthoclase, an axial dissimilarity of a new character presents itself. It is, namely, that though in the number and in relative irregularity of the individual axes, the framework of the two is the same, yet in the first named the axes all intersect at right angles; while with the last, certain of the axes intersect at oblique angles. This dissimilarity, while it does not seem to determine any of the great classes of physical differences in crystals, is yet the originator of a degree of dissymmetry unknown with crystals devoid of axial obliquity. It is of inestimable service in furnishing us with an additional basis upon which to carry our classification of crystals to an extent so exhaustive, that the various groups thus established are not unwieldy or complex, but simple and readily managed.

The analysis, to recapitulate, then, to which we have subjected various crystals in relation to their axes, has resulted in the detection of differences of three kinds, by which they can be rationally divided into groups and systems. To evolve these groups and their mutual relations is the last step to be taken. Proceeding from properties which affect the greatest number or the whole body of crystallized substances, we may be able to divide them all into several great groups; each of these may subsequently yield to subdivision by the presence or absence of certain properties less general than that which determined the first division, and this process of differentiation is continued until it ceases to be advantageous.

The most general division which can be made of crystals is one which depends upon the *number* of the axes. As has already been mentioned, these are in every case either three or four. It is possible, therefore, upon this principle, to establish two general groups, into one or the other of which, all crystallized substances will fall, viz., the triaxial and quadraxial groups. By far the greater number of crystals will be found to fall under the first of these groups, and by taking advantage of the knowledge derived from the examples previously given, this group (the triaxial) may be farther differentiated. The three axes of the group either intersect each other at right angles, or they do so at angles more or less oblique: the triaxial group may therefore be divided into two sub-groups—Orthometric from (Ορθος straight, and Μετρον, measure), in which all the axes form rectangular intersections; and Clinometric (from

Κλινω, I incline, and Μετρον, measure), in which one or more of the axes form oblique intersections.

By keeping still in mind the lesson learned from the example of the three minerals, a subdivision of the orthometric and clinometric sub-groups is readily managed. The only unapplied feature remaining is the relative inequality or differences in the lengths of the axes. This we will proceed to apply; and we are thus enabled to establish the following systems:

From the orthometric sub-group there may be obtained:

The Monometric (or Regular) system, in which the three axes crossing at right angles are all equal in length.

The Dimetric (or Quadratic) system, in which two of the three axes are equal in length, while the third is either greater or less.

The Trimetric (or Orthorhombic) system, which differs from the others in the essential particular that all the axes are unequal.

From the clinometric sub-group there may be obtained three systems, though only the two given below occur in nature.

The Monoclinic system, in which two of the three axes intersect obliquely, while the third cuts both of them at right angles.

The Triclinic system, in which each of the three axes forms an oblique intersection with the others.

The quadraxial group is not susceptible of further analysis, as but one system has as yet been recognized under it, namely: the hexagonal system: in which three of the four axes lie in one plane, intersect each other at an angle of 60°, and are equal in length; while a fourth axis of varying length is placed vertically upon them.

The study of the individual forms occurring under each of these systems, as well as the general character of the respective systems, will form the material for subsequent papers. The results of this exhaustive analysis, with the statement of which this note may close, are conveniently represented by the accompanying tabular arrangement.

GROUP.	SUB-GROUP.	SYSTEM.
TRIAXIAL,	*Orthometric*,	Monometric.
		Dimetric.
		Trimetric,
	Clinometric,	Monoclinic.
		Triclinic.
QUADRAXIAL,		Hexagonal.

PENNSYLVANIA'S FOUNDATION STONES.

Lecture delivered before the Franklin Institute, Thursday, Dec. 22d, 1870.
By Prof. Leeds.

(Continued from page 345.)

The Position of Pennsylvania in the Geological Scale.

The crust had hardened on the fiery deep. The earth had been one vast crucible. From myriad points ran out diverging lines of crystalline force, as when the first blasts of winter strike down upon the surface of the ponds. The school-boy hastening to the noisy class-room shouts with ecstasy, because he knows that these long needles of ice before nightfall will have linked themselves into a fast net-work, in whose loops a million tinier crystals shall be caught, and the whole shall have hardened into a faultless mirror. From point to point covering the globe with as many lines as those which show the mariner on his faithful chart his place upon the trackless deep, from zone to zone shot forth the rock crystals. A house that is to be built upon shifting sands must needs have firm foundation, a bridge that spans a torrent must root its abutments deep in either bank, and plant its piers like feet where the shock of the trunks and hulks of boats and huge stones carried down when springtime swells its stream into a freshet, can never budge them.

Upon the fiery lake that has no bottom, upon the lava that stretches down to the earth's centre, upon the flints and sand more liquid than what the fire-pot of the glass-house shows, upon molten metal, compared with which, the red hot rivulets that flow into the hissing troughs when the iron furnace is tapped, are cold and sluggish, a foundation is to be laid that shall endure until the last great day of doom. Over a fiery liquid which rose and fell with every change of moon, and rolled great tidal waves around the earth with the yearly and diurnal revolution of the sun—that piled itself up into a great mountain over 26 miles in height about the equator flung upwards from the poles as the earth spun round at the rate of 3 miles per second—that had its surface currents streaming onward to Polar Seas, and its submarine currents flowing downward towards the middle, as now the gulf and arctic streams change and purify the five great oceans—over this whirling tide a floor is to be laid upon which the bohemoth and the mastodon may walk without

the slightest tremor to terrify, and where the tiniest insect that enjoys the breath of life shall gambol in the sunshine, unconscious of the abyss that yawns beneath—over phosphoric fumes, that would fill the air with horror, over sulphurous vapors that would bleach and suffocate, over gases that would make of earth a sepulchre, a house is to be built that shall be man's glorious habitation.

Therefore were unyielding blocks of hornblende used for the foundation. And not only hornblende, but porphyry and basalt, and chiefly that most enduring building stone of all, solid granite. They were dovetailed and morticed one into the other by interlacing crystals, and where they showed signs of cracking, dykes of metal were pierced through, as builders key the walls of granaries and warehouses together with iron girders.

Thus was the foundation laid by which the vast superstructure was to be supported.

And when all had been done, and strength sufficient was given to last even to this present day, a great excess of material remained.

What was to be done with it?

It was to be made the soil and home of innumerable plants and animals.

When we wish that a plant should flourish, we dig about its root and break up the ground into clods, so that its tender rootlets may be strong enough to push their way through every chink and crevice, and find drink and nourishment awaiting them.

When an animal would live it tears its food to pieces, so that the juices may flow out and the acids of the stomach may seize upon each morsel of gelatine and fibre.

When the earth's first crust was to be made ready to receive plant-life and animal, it had to be ploughed up and harrowed, it had to be channelled and crevassed and scooped into hill and dale, and to be made soft, yielding, porous.

Things crystalline are strong but lifeless; things full of holes and cells are plastic, organic, living. Granites and porphyrys are good for foundation walls, but muds and sands make good ground for tillage.

Water, as I said in my first lecture, has been this great mediator between the inorganic and organic kingdom, the power which evoked life from the dead, and beauty and motion from the barren sea.

On a thousand millstreams water is busy in doing its work for man. It is grinding the crops into food. It is knitting fibre into

stuff. It is pounding the products of the furnace into bar and rail and bloom. Endless cranks and pulleys, levers, pistons, saws and hammers are spinning and whirling and falling at its bidding.

But how much of the power of the mill-stream is consumed after it has prepared man's tools, food and garments? With how much less energy does Niagara plunge headlong into the Emeral Pool because some child of mammon has perched an obscure papermill upon its brink?

With the first drop of rain that fell from the heaven above, with the first hill, however low, with the first lap of the ocean upon the shore, with the first heaving of the tide, water commenced to wear away the coping of the foundation and build up the superstructure. Fourteen miles of rock, piled one above the other, attest the thoroughness with which it has done its work.

I say fourteen miles instead of seven, as I stated at the outset, because I believe the considerations which have been brought forward are sufficient to overthrow the theory that the 37,000 feet that underlie the hitherto so-called fossil bearing rocks were the stratified sediments deposited upon the sea-bottom from the ashes of submarine volcanoes, viz., that the granites and other crystalline rocks found in these 37,000 feet graduate imperceptibly into gneiss and non-crystalline rocks; that the granites are interstratified with mud slates and other layers arising from the debris of crystalline rocks, and finally that fragments of crystalline rocks are found mingled in with sedimentary beds of later origin.

If any doubt remained it would be crushed by this little stone that I am now holding in my hand. It came from the Laurentian rocks of Canada. It was given by its discoverer, Dr. Sterry Hunt, the chemist of the Canadian survey, to my friend Mr. Trautwine, the eminent civil engineer of this city. It shows a polished surface of green serpentine, traversed with beautiful wavy lines of white marble. The latter are the crystallized tubes and branching canals of a coralline animal; the serpentine has taken the place of the flesh and body of the animal itself. The specimen shows that these Laurentian rocks were not devoid of life, but may have teemed with it. And since *this* specimen has been found, many others have been dug up throughout Canada and along the Gulf of St. Lawrence. The animal has been called the Eozoon Canadense—Eozooe, from two Greek words, one, Eos, signifying *dawn*, the other, zoon, meaning animal—the animal that was harbinger of the dawning of life upon

our globe. It has not only been found in Canada, but also in the limestones of Chelmsford, in north-eastern Massachusetts, showing that there, too, rocks but lately regarded as Azoic are of the Laurentian age, and contain fossils. The evidence has been rapidly accumulating during the course of the past five years, and already five more species have been found in rocks of a similar character. In great probability, now that the attention of naturalists has been called to the true nature of these beds, and instead of passing over them with indifference, geologists are everywhere examining them with the most careful scrutiny; before another five years have passed away, we may be made acquainted with not only five but with 50 different kinds of animals that flourished in the falsely called Azoic age.

If these 25,000 feet of Laurentian sediments contain life, it is opposed to all probability that the Huronian are devoid of any relics of it, and that an immense gap, during which 12,000 feet of muds and schists were deposited and centuries rolled away, intervened, during which no life existed upon our globe, and that a new creation took place at the opening of the Silurian age.

I said, in the beginning of the lecture, that it might be doubted whether anywhere there existed at the present day upon the face of the globe a fragment of the original crust that remained exposed to view: and that if it was to be found, it probably was along the line of the Laurentian Hills.

In the light of recent discoveries, may not even that doubt be regarded as dispelled? When the foundation had been laid, was it not meet and proper that that foundation should be concealed beneath the surface and only the superstructure appear?—when the granites and basalts, which are as little adapted to supply habitations for animals, or food for plants, or ores yielding to the art of man, as our modern traps and lavas, had served their use, that they should give way to something more soft and penetrable?

As dough is mixed through and through with leaven, so is the superstructure—(this more than dozen miles of sediment)—with the germs of life, with food and fuel, with oil, salt, metal, and even meat and flesh. Leavened, so that animals and plants, as they developed into forms of rarer beauty, and bloomed with brighter intelligences, should have that which nourish them onward to a higher life, until man should bud forth into the full and perfect flower of nature's creative energies.

Said Dean Swift, and this alone might atone for everything of savage and bitter that he said of frail and fickle manhood—"he that makes two blades of grass bloom where but one grew before, is a public benefactor." But in Swift's day, the chemist, the mineralogist and the geologist were unborn. What is to be said of him who, like the illustrious Prof. Hofmann, has found the secret of a hundred new dyes, and clothed the peasant with a robe more brilliant than that worn by a Tyrian king! What of the poor Philadelphia printer who robbed the tempest and the thunder cloud of its terrors! What of the poor bookseller's apprentice, who did more than any one else to make of electricity and magnetism vehicles that should outrun time and keep pace with thought! What of Count Rumford, the Yankee lad whom a Bavarian prince ennobled, and who first showed what was the proper amount and kind of food for rations for artisans and soldiers! What of Liebig, the father of organic chemistry, who taught us how to make food imperishable.

He that discovers a new continent does much, but he that finds that which will feed a continent of people does vastly more.

And in this superstructure, these piles of sediment, ready for use, are stored away fuel, light and food which we yet know little of.

Of its magazines of coal and its recently discovered wells of oil, we people of Pennsylvania know full well—and the riches, the comforts, the blessings that attend them we know. The government of Prussia is opening up yearly new mines of salt, and around those mines in the course of the last few years great factories have sprung that extract of the salt refuse its magnesia, and send their refuse to recuperate the exhausted lands of our own Southern States with the potash which they contain.

Salts of iodine and bromine are being mined, so that these bodies, invaluable to medicine and photography, are sinking in price so rapidly as to be constantly employed for fresh uses.

As our vast cities grow, they must be fed, and new substances must be dug from the ground to supply the wants which a denser and more cultured population bring.

Therefore must every geologist examine more critically the country about us, and the chemist must put its soils and minerals and ores to a more searching test to find something of new value.

Therefore must an enlightened public do, of its free will, what the monarchies of Europe do by compulsory taxation, and found

laboratories and institute surveys, which may discover and provide beforehand for the needs of a growing population.

The chemist and geologist have their high and appointed vocation as much as priest or politician. A Franklin, who turns away from the splendor of courts to perfect electrical machines, and a Faraday, who put away from him during the course of a lifetime a quarter of a million of pounds sterling, and preferred the public good to riches, are not the least noble of those who say "the common wealth is their greatest wealth, the public weal their highest good."

Perhaps there are some here who will have an instrumentality in solving some of the problems which I have brought before you to-night—some who may make the glorious discovery that these foundation stones of Eastern Pennsylvania, those which we have so often tramped over before, looking only for the minerals they contain, are not Azoic, but have once been peopled with life. To bring into order what has hitherto baffled the knowledge of geologists, to show precisely of what age these rocks are, and, if possible, to detect the broken and confused relics of crab and shell which they may contain, I solicit the help and study of every young student in my audience. And to encourage and stimulate us by your interest and sympathy, to found for us laboratories wherein we may successfully examine the material that we have gathered from the fields or dug from beneath the hills, I turn to you, my older friends and much valued fellow-members of the Institute.

ON A NEW CONNECTION FOR THE INDUCTION COIL.

By Prof. EDWIN J. HOUSTON.

THE following experiments were made at the Central High School of Philadelphia, with the view of increasing the quantity of the spark of the induction coil without greatly diminishing its length. The instrument used was made by Ritchie, of Boston, and will throw the spark six inches in free air.

One of the poles or ends of the secondary wire was connected with the earth by a copper wire attached to a gas pipe. The other pole was connected with a wire, which rested on a large lecture table holding the coil. On turning the break piece, the electricity, instead of being lost by passing along the wires to the earth, jumped

from the pole connected with the table, to that connected with the earth. The thickness of the spark was greatly increased, its length diminished, and its color changed to a silvery white, as when a Leyden jar is placed in the path of the discharge.

While the electricity is flowing between the points, long sparks may be drawn from any part of the table, or from any metallic article within eight or nine feet of the coil. On one occasion the gas was lighted by a spark drawn from the finger of a person standing on the floor. The gas pipe being in almost perfect connection with the earth, the spark must have been given to it from the body of the person.

On another occasion one wire was attached to the gas pipe as before, and the other to a stove, whose pipe connects with that of another stove in an adjoining room. The thickness of the spark was greatly increased. Sparks were drawn from the distant stove, and even from a small steam engine, which latter was fully thirty feet from the coil. In all the experiments it was found necessary to insulate the handle of the break piece, as a slight shock was experienced at every break. The poles being kept at a distance from each other less than the insulating power of the coil, six inches, no danger of injuring the instrument was apprehended. In one instance sparks were drawn, in a room underneath the adjoining room, from a wire which connected with the table on which the coil rested.

These facts showing great loss of the electricity, but indicating the need for a large conductor, probably to allow the rapid discharge of the secondary wire, a large insulated conductor was extemporized by placing some old tin stills and percolators on large glass jars. On connecting one of the poles with this conductor, and the other with the gas pipe, the quantity of the spark was increased, though there was reason to believe that, with a larger conductor, better results would have been obtained. The conductor was then divided into two, of about equal size, which were connected with the poles. The quantity of the spark was increased, with, however, great diminution in the length. By successively diminishing the size of one of the conductors, and increasing that of the other, the length of the spark was increased, without any sensible diminution in its quantity, until, when one of the conductors was less than one square foot in surface, a fine quantity spark of about *five inches* was obtained.

It will be noticed that this connection is somewhat similar to that used in the common cylinder or plate machine, in which one of the conductors, generally the negative, is connected with the earth, and the quantity of the electricity thereby increased.

In all the experiments in which one pole was in partial connection with the earth, as when it rested on the table, the loss of electricity must have been very great, for several gas and water pipes are in connection with the table. If, then, the table merely serves as an imperfectly insulated conductor, which allows the rapid induction of electricity in the secondary wire by its rapid discharge, and thereby, notwithstanding the loss, gives so great an increase in the quantity of the spark, it would seem that if, instead of the table, an insulated conductor of very large surface were used, a much greater increase in quantity would be obtained.

It would seem from the above experiments that the maximum increase will be obtained when one of the poles is connected with an insulated conductor, say several hundred square feet in surface, and the other with the earth.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaelis, for the Journal of the Franklin Institute.]

By Adolph Ott.

(Continued from page 337.)

On the Preparation of the Mixture.

In preparing hydraulic mortar, it is advisable to begin in mixing the dry lime or cement-powder with clean sand. When these form a thorough mixture, the requisite quantity of water must be gradually added under constant stirring up of the material. In no other way can a uniformly and evenly mixed mortar be obtained with rapidly binding lime or cement; while, if the lime or cement is first mixed with water, a partial binding and consequent clogging of the material takes place, which either precludes the possibility of a perfect and satisfactory mixture of the sand then added, or renders it at least extremely difficult.

It is self-understood that the water must be clean, that is to say, free from all such substances as may interfere with the adhesion of the particles, like clay, mud, grease and mucilaginous matter.

The mixture of water ought to be such as to secure a product of the most even consistency; this is no doubt obtained with less difficulty and more chance of success through the use of mortar-

machines. If, however, the mixure has to be made by hand-work, careful and reliable persons ought to be chosen for the work, which should be paid for by the day or week, and not given out under contract.

It is of especial importance not to make the mortar too soft, because, as we have already repeatedly shown, and as has been proven by numerous experiments, the quality and solidity of the mortar is directly dependent on the quantity of water it contains at the moment of its hardening.

While very good Portland cement, for instance, requires only 30 parts in weight of water for every 100 parts in weight of cement to produce a mortar of sufficient consistency, there are other descriptions which must be mixed with at least 40 parts of water; but as in either case the quantity of water chemically bound is almost precisely the same, and as the surplus water evaporates in course of time, it is evident that the density and solidity of the former cement must be far greater than that of the latter.

With very good Portland cement, however, the disadvantage of an excessive admixture of water is averted, in a great measure, in consequence of its specific weight and peculiar powder-like form, which cause its speedy settling towards the bottom, and its effectual separation from the surplus water; but another inconvenience frequently arises in the separation of the mortar-mass, inasmuch as the coarser particles settle near the bottom, while the finer ones remain nearer to the surface. Whenever other descriptions of hydraulic lime or quickly hardening cement are used, the quantity of water to be admixed must be most carefully measured, or its due proportion ascertained by previous repeated experiments.

An especially careful preparation is necessary for pozzuolana mortar, because with them all reactions are expected to take place after the mixture has been completed.

The mixture of hydrate of lime and pozzuolana must be as dense and thorough as possible.

The pozzuolana ought to be reduced to very fine powder, and the mixture with the lime must be as effective and intimate as possible.

The use of a machine like Hertel's combined clay cutting apparatus is most commendable for this purpose; because the greatest possible density and uniformity of the mixture is thus obtained.

The preference must, in all instances, be given to the employment of machine power, because it is impossible to obtain a satis-

factory mixture by hand-work in any other way than through a plentiful use of water. The result of this excessive admixture of water, however, is a soft, pap-like substance, which can never be made into a dense and solid mortar. It shrinks speedily, gets cracky, and yet remains slack. In cases where pozzuolana mortar is to be exposed to the influence of the turbulent sea, and where its strength and solidity is therefore most severely tried, the greatest care in its preparation is advisable. Nothing which may tend to increase its durability ought to be overlooked. In looking over the numerous directions given for the preparation of such mortar, it is surprising to see the wide difference of the several methods recommended, and the proportionately small quantity of lime almost universally advocated.

The former circumstance finds its explanation in the different descriptions of pozzuolana, or in the local peculiarities and influences of the places where it is found, or where it is to be used; and it is even advisable to experiment with regard to the various proportions of material to be used, in order to ascertain how to attain the most favorable result in any special case.

The second point, however, is worthy of a more minute consideration. In defining the hardening process of pozzuolana mortar, we have already made the remark that a great portion of the pozzuolana remains ineffective, in consequence of the relatively small quantity of lime used in its preparation.

This limited use of lime we explain in the following manner:

Whenever there is a great surplus quantity of pozzuolana the lime finds a sufficient quantity of easily accessible and binding substances, as silicic acid, alumina, &c.; in a short while the quicklime is thus almost completely converted into hardening compounds, and the consistence of the mortar is likewise secured in a comparatively small lapse of time.

But if, on the contrary, pozzuolana mortar is mixed with a quantity of lime capable of securing the only possible hydraulification of the lime, a very large proportion of this base would, for a long time, remain in the substance as quicklime; during this period the power of resistance as well as the density of the mortar would be materially impaired, while under water, through the agency of such an easily soluble substance; and it would take a long time before such mortar could resist the influence of water.

It is better, therefore, to renounce such proportion of the hydrau-

lificating faculty as would only become effective after a long lapse of time in all cases where water-mortar is to be made with pozzuolana for immediate use.

It is, however, undoubtedly advisable to take a greater proportion of lime, and to allow more time, in order that the various substances of which the mixture may be composed can have full chance to act upon one another before the mortar is brought into use.

In so doing, the following advantages are secured:

(1) The chemical reactions will be more complete.

(2) In consequence of the more uniform course of these reactions, the substance becomes more dense, and the consistence of the mortar, subsequent to the hardening process, is more safely secured.

After the pozzuolana has been reduced to the finest powder, it is mixed with lime, which must be previously reduced to a stiff, paplike condition; to these materials a sufficient quantity of water has to be added to produce a mass of a certain consistence. The use of Hertel's clay cutting apparatus or of a similar machine is advisable. After leaving the substance alone for a few days, the mixing process has to be repeated several times with the addition of the requisite quantity of water.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, February 15th, 1871.

THE meeting was called to order at the usual hour, the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting held March 8th, inst., donations to the library were received from the Society of Arts, the Institute of Civil Engineers, and Lieut. Col. Edward Sabine, London, England; Hon. Secretary of State, Hon. William D. Kelley, Washington; American Philosophical Society, Dr. E. P. Wyckoff, and Messrs. Hillibrand and Wolf, Philadelphia.

The committee appointed to report on the estimation of H. P. of engines and boilers reported progress.

The Secretary then read his monthly report on Novelties in Science and the Mechanic Arts, after which the Institute adjourned.

W. H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, March 15th, 1871.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at a meeting held at the Hall, the Board organized in accordance with the annual election of January 25, by electing Bloomfield H. Moore and Charles Bullock, Curators; and William Hamilton, Actuary for the ensuing year; and by appointing the following standing committees:

On Instruction.

William H. Wahl,
Robert E. Rogers,
Enoch Lewis,
Washington Jones,
Robert Briggs.

On Elections and Resignations.

Henry G. Morris,
Henry Gartwright,
Clarence S. Bement,
William Helm,
Theo. Bergner.

On Stocks and Finance.

William Sellers,
Frederick Fraley,
J. Vaughan Merrick,
Enoch Lewis,
William P. Tatham.

On Publication.

Bloomfield H. Moore,
Samuel Sartain,
Charles Bullock,
Pliny E. Chase,
Joseph M. Wilson.

On Exhibitions.

J. Vaughan Merrick,
William Sellers,
Charles S. Close,
Bloomfield H. Moore,
Edward H. Williams.

On Sections.

John H. Cooper,
R. Egglesf. Griffith,
H. W. Bartol,
W. B. Le Van,
Hector Orr.

Furthermore, that at the stated meeting of the Board, held February 8th, 1871, donations to the library were received from the Royal Astronomical Society, the Royal Geographical Society, and the Institute of Civil Engineers, London, Eng., and the Steam Users' Association, Manchester, Eng.; the K. K. Geologischen Reichsanstalt, Vienna, Austria; the Natural History Society, Montreal, Canada; Col. James B. Eads, Chief Engineer Illinois and St. Louis Bridge; E. S. Cheesborough, City Engineer, Chicago, Ill.; John W. Bast, Surveyor General of California; and from D. Sheppard Holman, Philadelphia.

The resignations of membership in the Board were received, of Messrs. John Birkbeck and Clarence S. Bement, and accepted, with the order to be reported at the next meeting of the Institute. The

committee appointed at the last meeting to consider the mode of estimating the H. P. of boilers and engines reported progress.

The Secretary's report on Novelties in Science and the Mechanic Arts was then read.

Under the head of new business, the President announced the appointment of the following gentlemen upon the committees of the Institute for the ensuing year, to wit:

Library.

Charles Bullock,
Samuel Sartain,
Wm. P. Tatham,
Henry G. Morris,
Jos. M. Wilson,
Wm. H. Wahl,
Bloomfield H. Moore,
John C. Browne,
Percival Roberts,
Pliny E. Chase.

Arts and Manufactures.

William Adamson,
John H. Cooper,
Jacob Naylor,
Hector Orr,
Wm. G. Rhoads,
William P. Tatham,
Rafael Estrada,
James Sellers Bancroft,
Alfred Mellor.

Models.

Wm. B. Bement,
Edward Williams,
Ewd. Brown,
Theodore Bergner,
John Goehring,
D. S. Holman,
William B. Le Van,
Edwin Smith,
Charles McIlvain,
Addison Hutton.

Meteorology.

Isaac Norris, Jr.,
Robert E. Rogers,
William H. Wahl,
John Wise,
Thos. S. Speakman,
James A. Kirkpatrick,
Pliny E. Chase,
David Brooks,
Alexander Purvis,
John G. Moore.

Minerals.

John C. Trautwine,
F. A. Genth,
Theo. D. Rand,
R. Egglesfield Griffith,
Albert R. Leeds,
Clarence S. Bement,
S. B. Howell,
John C. Browne,
William H. Wahl,
Albert C. Peale.

Meetings.

Henry Cartwright,
Enoch Lewis,
Robert E. Rogers,
Ed. Longstreth,
B. C. Tilghman,
Bloomfield H. Moore,
Charles S. Close,
William H. Wahl,
Henry G. Morris,
R. E. Griffith.

The election of two members of the Board was ordered to fill vacancies caused by the resignation of Messrs. Birkbeck and Bement. Mr. Wm. Wharton, Jr. and B. C. Tilghman were, upon balloting, declared duly elected.

The meeting then adjourned.

WM. H. WAHL, *Secretary.*

INDEX.

PAGE.

Air-Meter,—Castella's 362
Allen Engine. By Chas. T. Porter 22
Allen, Dr. J. G.—Heating and Ventilating R. R. Cars 217
Alloy for Joining Brass with Steel or Iron 219
American Journal of Science and Arts 72
Ammonia and the Solubility of Metals without Chemical Action. By Chas. A. Seely 110
Anomalous Spectra 299
Approach caused by Vibration 157
Arithmometer 372
Articulite, (Itacolumite). By Prof. A. M. Edwards 11
Artificial Coloring of Wines,—Detection of 369
Production of Coniin 230
Indigo 197

Balloon as an Instrument in Meteorological Research,—On the. By John Wise, 345
Band Saw Mill of Unusual Size 219
Bancker Collection,—The 375
Belting Facts and Figures. By J. H. Cooper 17, 107, 184, 267, 317
Bibliographical Notices:—
Kansas City Bridge. By O. Chanute, (Van Nostrand & Co.) 141
On the Hypothesis of Evolution. By Prof. E. D. Cope, (C. C. Chatfield & Co.) 143
Explosions of Steam Boilers. By J. Robinson, (Little, Brown & Co.,) 287
The Elements of Astronomy, School Edition. By J. Norman Lockyer, (D. Appleton & Co.,) 288
Elements of Machine Drawing and Construction. By S. E. Warren, C. E., (J. Wiley & Son, N. Y.,) 360
Report of the Trustees of the Rensselær Polytechnic Institute Concerning the System of Instruction &c 360
Bisulphide of Carbon,—Solid 371
Blower,—The Root 294
Blow-Pipe Assay with the Automatic Air-Blast. By Le Roy C. Cooley, Ph.D. 64
Blowing out Broken Piles 75
Boiler Incrustation 151
Boiling Produced by Commingling Immiscible Liquids 158
Boiler Explosions 289
Inspection 291
Bone Cave,—Discovery of a 302
Boston Bay,—A Tunnel under 363
Bridge between Camden and Philadelphia 3
Illinois and St. Louis 73
Triangular Suspension 74
East River 75
Kansas City 141
Across the Hudson River near New York 152
Brown, Edward,—On the Horse-Power of Steam Engines and Boilers, and some Facts connected with the Expansion of Steam 187
Browning's Spectroscopes 153
Broken Piles,—Blowing out 75
Bullets Melted by Impact 158
Bunsen Filter Pump 223

PAGE.

Caisson of the East River Bridge 364
Cape Cod,—On a Ship Canal across. By J. P. Frizell, C. E 386
Castella's Air Meter 362
Census of 1870 365
Change of Color Produced by Heat in Certain Iodides 158
Cheap Voltaic Decomposition Apparatus 78
Childs, Col. O. W.—Survey of the Nicaragua Route for a Ship Canal, 25, 240, 363
Chloral Hydrate,—On. By Robert F. Fairthorne 327
Chronograph,—Improved 225
Cold on Iron and Steel,—Effect of 295
Compounding Steam Engines 222
Compressed Air as a Motor 79
Leather 82
Composition of the Shell of the *Lingula Pyramidata*. By Prof. Charles P. Williams 278
Coincidence of Terrestrial Magnetic Change with Solar Action 156
Condenser,—Ernst Alban's 220
Convenient Form of Gas Furnace 229
Corrugated Flames 296
Cornish Engines. By W. H. G. West, U. S. N 174, 243, 304
Cooley, Le Roy C., Ph.D.—On a Blow-Pipe Assay with the Automatic Air-Blast 64
Cooper, J. H.—Belting Facts and Figures 17, 107, 184, 267, 317
Cylindrical Surfaces,—On a Machine for Producing True. By J. Morton Poole, 392
Crystallography,—Notes on. By W. H. Wahl 406

Delaware Bridge between Philadelphia and Camden. By Hector Orr 3
Detection of the Artificial Coloring of Wines 369
Directional Rain Gauge 10
Discovery of a Bone Cave 302
Dispatch Tube,—Pneumatic 294
Dispersion of Light,—Two Notes on. By M. Th. Ricour. (Trans. by Prof. C. A. Young) 48
Distinctness of Sound,—Facts Relating to the 80
Dutton, Lieut. C. E.—On the Use of Pulverized Fuel 377

Earthwork,—Rules &c. for the Calculation of. By John Warner, A. M 396
East River Bridge 75
Caisson of the 364
Eclipse Parties, U. S.—Preliminary Reports from the 137
of December 22d, 1870 ..... 15, 80, 82, 88, 137
Party of the Naval Observatory 80
Editorial Correspondence—
Eclipse of December 22d, 1870, by Prof. C. A. Young 82
By Prof. S. P. Langley 88
Prof. J. E. Nourse on the Suez Canal 303
Effect of Cold on Iron and Steel 295
Electric Light 150
Electric Star,—Gassiott's 227
Erbswurst,—Pea Sausage 14
Examination of Some Experimental Facts Bearing upon the Proper Ratio of Length and Breadth of Steamships. By Alban C. Stimers, N. E. 260, 305, 401

Engineering of the Period. By Wm. M. Henderson, Hyd. Eng 45
Engineers and Machinists. By J. Richards, M. E 315
Engraving arom Photographic Negatives 222
Engine,—New Air 153
Engines,—Cornish. By W. H. G. West, U. S. N 174, 243, 304
Magnetic. Their Possible Duty 149
Galvanic 299
Ernst Alban's Condenser 220

PAGE.
Evans, W. W., C. E.—The Fairlie Engine 102
Evolution as Affecting the Earth's Crust. By Prof. A. R. Leeds. 129, 202
Experiments,—New 229, 297
Explosions,—Steam Boiler 289
of Steam Boilers. By J. Robinson 287

Facts Relating to the Distinctness of Sound 80
Facts and Figures,—Belting. By J. H. Cooper 17, 107, 184, 267, 317
Fairlie Engine. By W. W. Evans, C. E 102
Fairthorne, Robert F.—On Chloral Hydrate 337
Ferrel, Wm.—Determination of the Mass of the Moon from Observation of the Tides 366
Ferry Boat,—Screw Propellor 152
Ferricyanide of Potassium, Sensitiveness to Light of 228
Fire Escape and Ladder 148
Fire-Proof Safes 361
Filter-Pump,—Bunsen's 223
Flames,—Corrugated 296
Franklin Institute—Proceedings of 15, 81, 143, 144, 286
Frizell, J. P., C. E.—On a Ship Canal across Cape Cod 386
Furnace Slag,—Utilization of 53

Galvanic Batteries with Nitric and Chromic Acids 228, 370
Engines 299
Gas Press,—Hydrostatic 9
Furnace of Convenient Form 229
Gassiott's Electric Star 227
Gauge,—A Directional Rain 10
Gold Refining by Chlorine 160
Gould, Dr. B. A.—The Sun 66, 133, 198
Graphical Method. By Prof. Edward C. Pickering 272
Gun Cotton and Gunpowder 364
Guthrie, Fred.—Approach Caused by Vibration 157

Horse-Power of Steam Engines and Boilers, and Some Facts Connected with the Expansion of Steam. By Edward Brown 187
Haskins, J. F.—Compressed Air as a Motor 79
Heating and Ventilating Railway Cars,—A New Method of 217
Henderson, Wm. M., Hyd. Eng.—Water Works for the People 180
Engineering of the Period 45
Hoosac Tunnel 145
Hudson River,—Bridge across the—near New York 152
Hydrostatic Gas Press 9
Hydraulic Mortar,—On the Use of. By Dr. W. Michaelis 281, 332, 419
Hypothesis of Evolution,—On the. (C. C. Chatfield & Co) 143

Incrustation of Boilers 151
Ingenious Application of the Spectroscope 296
Injectors and Pumps 150
Illinois and St. Louis Bridge 73
Illuminating Gas,—On the Reduction of Light due to the Presence of Carbonic Acid in. By Fred. E. Stimpson 54
Immiscible Liquids,—Boiling Produced by Commingling of 158
Improved Pocket Chronograph 225
Improvements in Safety Lamps 293
Indestructible Metallic Packing 271
Indigo,—New Solvent for 368
Artificial Production of 197
Induction Coil,—On a Large. By Wm. H. Wahl, Ph.D 213
Inspection,—Steam Boiler 291
Iron Manufactures in Great Britain. By Prof. R. H. Thurston, Engineer, U. S. N 69, 161, 253, 320

PAGE.

Iron and Steel,—Effect of Cold on 295
Iron,—Turning of 76
Itacolumite (Articulite) 11

Joining Brass with Steel and Iron,—An Alloy for 219
Journal of the Franklin Institute, January, 1868 ..... 15, 81

Kansas City Bridge. (Van Nostrand & Co.) 141
Kohlrausch, F.—Observations on Siemen's Unit 349

Laboratory Appliances. By Prof. A. R. Leeds 207
Ladder and Fire Escape 148
Lamy,—A New Pyrometer 13
Langley, Prof. S. P.—On a New Form of Solar Eye-Piece 115
On the Eclipse of Dec. 22d, 1870 88
Lantern,—The Vertical 300
Large Band Saw Mill 219
Induction Coil. By Wm. H. Wahl, Ph.D 213
Leaden Bullets Melted by Impact 158
Lead Pipes as Water Conduits 224
Leather,—Compressed 82
Lecture Experiments,—New 229, 297
Experiments. By Prof. James Thompson 210
..... 229
on a Grand Scale 153
Leeds, Prof. A. R.—On Evolution as Affecting the Earth's Crust 129, 202
Pennsylvania's Foundation Stones 337, 412
Leibius', Prof.—Method of Reducing Silver Chloride 160
Lens,—A new, for the Microscope 77
Light,—Electric 150
Lingula Pyramidata,—On the Composition of the Shell of. By Prof. Chas. P. Williams 278
List of Observations on the Polarization of the Corona. By Prof. Edward C. Pickering 58
Loose Pulley,—Self-Oiling 75
Loss by Volatilization in Certain Metallurgical Operations,—On Some of the Conditions of. By Prof. Chas. P. Williams 123
Lubricator. By David Adamson 8

Machine for Producing True Cylindrical Surfaces,—On a. By J. Morton Poole 392
Magnetic Spectra,—On a Method of Fixing, Photographing and Exhibiting. By A. M. Mayer, Ph.D 355
Magnetic Battery,—Maximum Magnetic Effect Evolved by 159
Engines. Their Possible Duty 149
Map of the Isthmus of Darien. By John C. Trautwine 43
Maximum Magnetic Power Evolved by a Magnetic Battery 159
Mayer, Prof. A. M., Ph.D.—On a Method of Fixing, Photographing and Exhibiting the Magnetic Spectra 355
Mechanical Engraving from Photographic Negatives 222
Metallic Packing,—An Indestructible 271
Meteorological Research,—The Balloon as an Instrument in. By John Wise, 345
Method of Fixing, Photographing and Exhibiting the Magnetic Spectra.—On a. By Prof. A. M. Mayer, Ph.D 355
Michaelis, Dr. W.—On the Use of Hydraulic Mortar. Trans. by Dr. Adolph Ott 281, 332, 419
Misuse of a Symbol 367
Monster Blast 222
Mont Cenis Tunnel 292
Moon,—Determination of the Mass of, by Observation of the Tides 366
Motor,—Compressed Air as a 79

PAGE.

Naval Observatory Eclipse Party 80
New Air Engine 153
Danger to Ocean Cables,—A new 365
Experiments 229, 297
Fire Escape and Ladder 148
Form of Solar Eye-Piece. By Prof. S. P. Langley 115
Lens 77
Pyrometer. By M. Lamy 13
Solvent for Indigo 368
Nicaragua Route for a Ship Canal,—Survey of the. By Col. O. W. Childs, C. E. 25, 240, 363
Noble, Capt.—Misuse of a Symbol 367
Notes on Crystallography. By W. H. Wahl 406
Nourse, J. E., U. S. N.—The Suez Canal 238

Observations on Siemens' Unit. By F. Kohlrausch 349
Ocean Cables,—A new Danger to 365
Telegraph,—Running Speed 152
Occurrence of Saltpetre 229
Old Invention,—An 293
Optical Section,—Proceedings of 77
Orr, Hector,—Delaware Bridge between Camden and Philadelphia 8
Ott, Dr. Adolph,—On the Use of the Hydraulic Mortar. Translated from Die "Hydraulische Mörtel" of Dr. W. Michaelis 281, 332, 419

Parrish, Prof. Edward,—On the Rectification of Petroleum 117
Pea Sausage,—Erbswurst 14
Petroleum,—Rectification of. By Prof. Edward Parrish 117
Pennsylvania's Foundation Stones. By Prof. A. R. Leeds 337, 412
Pennsylvania R. R. Shops at West Philadelphia. By Jos. M. Wilson, C.E., 96
Photographic Negatives,—Mechanical Engraving from 222
Photometry in Rail Making 363
Pickering, Edward C.—List of Observations on the Polarization of the Corona. 58
The Graphical Method 272
Pneumatic Dispatch Tube 294
Pocket Barometer 226
Poole, J. Morton.—Machine for Producing true Cylindrical Surfaces 392
Porter, Chas. T.—Allen Engine 22
Possible Duty of Magnetic Engines 149
Preliminary Reports from the U. S. Eclipse Parties 137
Proceedings of Franklin Institute, March 16th, 1870, 143; Dec. 21st, 1870, 144; Jan. 18th, 1871 ..... 286, 422
Production of Coniin,—Artificial 230
Proportion of Sliding Surfaces 294
Pulley,—Self-Oiling Loose 76
Pulverized Fuel,—On the Use of. By Lieut. C. E. Dutton 377
Pumps and Injectors 150
Pyrometer,—A new 13

Ratio of the Length and Breadth of Steamships,—An Examination of Some Facts Bearing on the. By Alban C. Stimers 260, 305, 401
Railway Ties in South America 294
Cars,—Heating and Ventilating of 217
Railroad Wheels,—Varied Strain on 152
Rain Gauge,—Directional 10
Richards, J. E.—Wood-Working Machinery 39, 89, 233, 310
Engineers and Machinists 315
Rectification of Petroleum. By Prof. Edward Parrish 117
Reducing Silver Chloride 160
Reduction of Light Due to the Presence of Carbonic Acid in Illuminating Gas. By Fred. E. Stimpson 54
Refining Gold Chlorine 160

PAGE.

Rammelsberg, C.—Yttrocerite 15
Remarkable Color Change Produced by Heat in Certain Iodides 158
Spectrum 226
Rensselær Polytechnic Institute. Report of Committee upon the System of Instruction, &c 358
Reversal of the Sodium Line 369
Ricour, M. Th.—Two Notes on the Dispersion of Light 48
Road Steamers 218
Root Blower.—The 294
Roscoe, Prof.—Researches on Vanadium 298
Running Speed of Ocean Telegraph 152

Safes,—Fire-Proof 361
Saltpetre,—Occurrence of 229
Scientific Lecture on the Grand Scale 153
Screw Propellor Ferry Boat 152
Seely, Chas. A.—On Ammonia and the Solubility of Metals without Chemical Action 110
Self-Oiling Loose Pulley 76
Sellers, Coleman.—On Tilghman's Process of Cutting Hard Substances 193
Sensitiveness to Light of Ferricyanide of Potassium 228
Ship Canal Across Cape Cod,—On a. By J. P. Frizell, C. E 386
Siemens' Unit,—Observations on. By F. Kohlrausch 349
Silver Chloride,—Reduction of 160
Sliding Surfaces,—Proportion of 294
Sodium Line,—Reversal of the 369
Solar Action,—Coincidence of Terrestrial Magnetic Change with 56
Eclipse of December 22d, 1870 ..... 15, 80, 82, 88, 137
Eye-Piece,—On a New Form of 115
Solid Bi-Sulphide of Carbon 371
Solubility of Metals without Chemical Action, &c. By Chas. A. Seely 110
Solvent for Indigo 368
Sound,—Distinctness of 80
South America,—R. R. Ties in 294
Spectra,—Anomalous 299
Spectroscope,—An Ingenious Application of the 296
Application to Determine Quantities of Coloring Matters 368
Browning's 153
Spectrum,—Remarkable 226
Speed of Telegraph Transmitters 222
Steam Boiler Explosions 289
Inspection 291
Steam Engine,—A Veteran 218
Engines and Boilers, Horse Power of, and some Facts Connected with the Expansion of. By Edward Brown 187
Engines,—Compounding 222
Steel and Iron,—Effect of Cold on 295
Tyres 151
Stimers, Alban.—An Examination of some Experimental Facts Bearing upon the Proper Ratio of the Length and Breadth of Steamships 260, 305, 401
Stimpson, Fred. E.—On the Reduction of Light due to the Presence of Carbonic Acid in Illuminating Gas 54
St. Louis Bridge 73
Suez Canal. By Prof. J. E. Nourse, U. S. N 238
Sun,—The. By Dr. B. A. Gould 66, 133, 198
Survey of the Nicaragua Route for a Ship Canal. By Col. O. W. Childs, C.E, ... 25, 240
Suspension Bridge,—Triangular 74

Telegraphic Possibilities 10
Telegraph,—Running Speed of Ocean 152
Transmitters,—Speed of 222

PAGE.

The Elements of Astronomy. By J. Norman Lockyer, F. R. A. S., American School Edition 288
Thurston, Prof. R. H.—Iron Manufactures in Great Britain 29, 161, 253, 320
Thomsen, Prof.—Lecture Experiments 210
Tighlman's Process of Cutting Hard Substances. By Coleman Sellers. 193
Tinning of Iron, &c 76
Trautwine, John C.—Map of the Isthmus of Darien 43
Triangular Suspension Bridge 74
Tunnel,—Hoosac 145
The Mont Cenis 292
under Boston Bay 363
Two Notes on the Dispersion of Light. By M. Th. Ricour. Translated by Prof. C. A. Young, Ph.D 48
Tyres,—Steel 151

Use of Hydraulic Mortar. By Adolph Ott. Trans. by Dr. M. Michaelis, ... 281, 332, 419
Use of Pulverized Fuel,—On the. By Lieut. C. E. Dutton 377
Utilization of Furnace Slag 53

Vanadium 298
Varied Strains on Railroad Wheels 152
Ventilating and Heating Railway Cars 217
Vertical Lantern,—The 380
Veteran Steam Engine 218
Vibration,—Approach Caused by. By Frederick Guthrie 157
Volatilization in Certain Metallurgical Operations,—On Some of the Conditions of Loss by. By Prof. Chas. P. Williams 123
Voltaic Decomposition Apparatus,—On a Cheap Form of 78

Wahl, W. H.—A Large Induction Coil 213
Notes on Crystallography 406
Warner, John, A. M.—Rules, Formulæ, &c., for the Calculation of Earthwork, 396
Water Works for the People. By Wm. M. Henderson, Hyd. Eng 180
Conduits,—Lead Pipes for 224
West, W. H. G., U. S. N.—Cornish Engines 174, 243, 304
Williams, Prof. Chas. P.—On the Composition of the Shell of the *Lingula Pyramidata* 272
Williams, Prof. Chas. P.—On some of the Conditions of Loss by Volatilization in Certain Metallurgical Operations 123
Wilson, Jos. M., C. E.—Pennsylvania R. R. Shops at West Philadelphia 96
Wines,—Detection of Artificial Coloring of 369
Wise, John,—On the Balloon as an Instrument in Meteorological Research, 345
Wood-Working Machinery. By J. Richards, M. E 39, 89, 233, 310
Woodward, C. J., B. Sc.—On a Cheap Voltaic Decomposition Apparatus 78

Young, Prof. C. A.—On the Eclipse of Dec. 22d 82
Yttrocerite 15